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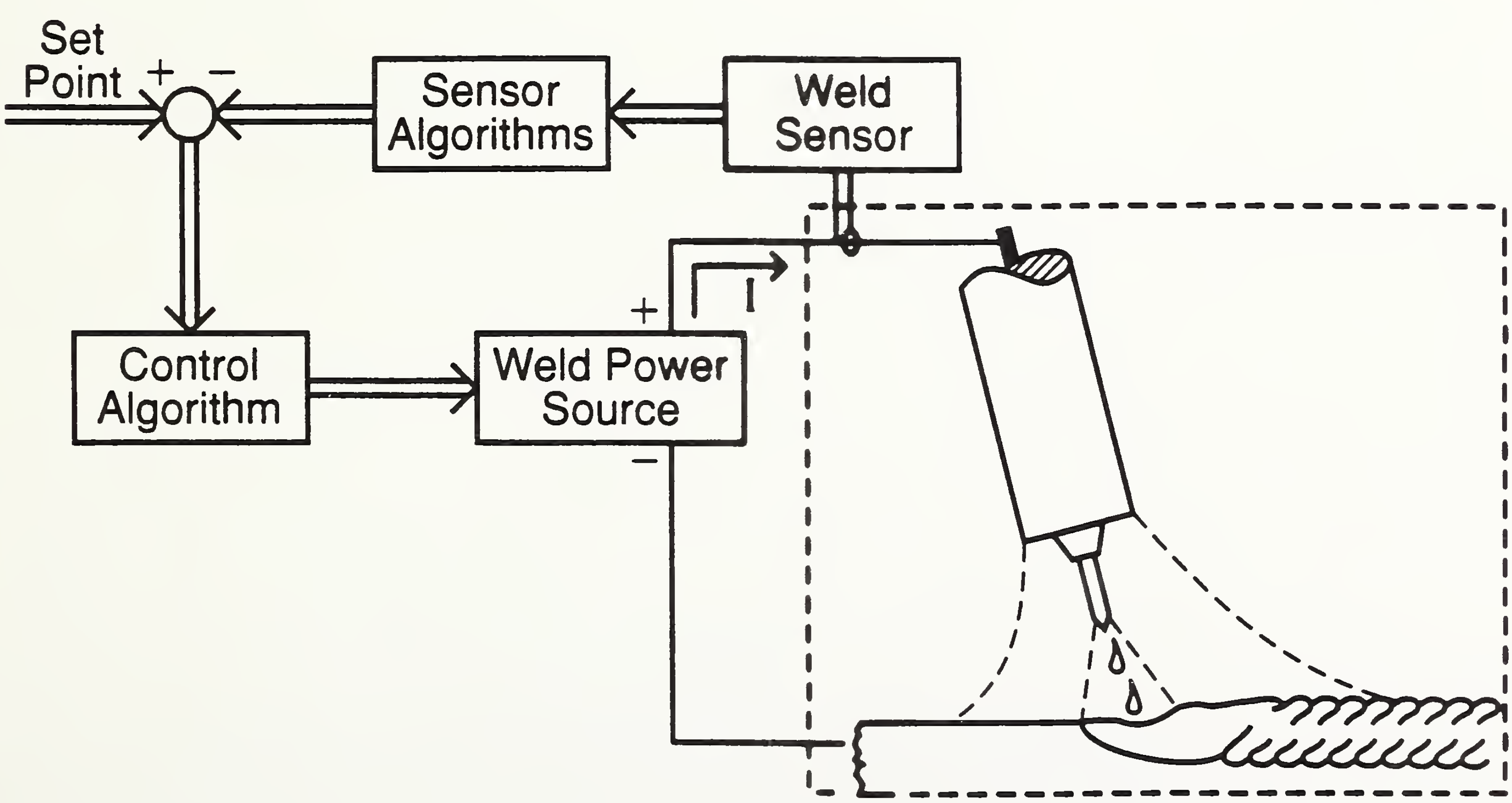

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DROPLET TRANSFER MODES FOR A MIL 100S-1 GMAW ELECTRODE

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ABSTRACT

Welds were made with a 1.2-mm-diameter MIL 100S-1 electrode using Ar-2% O_2 shielding gas to investigate the effects of contact-tube-to-work distance (13, 19, and 25 mm) on metal transfer. The transfer modes were identified by the sound of the arc, images from a laser back-lit high-speed video system, and digital records of the voltage and current fluctuations. The spray transfer region was mapped on a current-voltage plot, with a range that included the boundaries of adjacent transfer modes. The metal transfer mode boundaries shifted with an increase in contact-tube-to-work distance. Increasing the contact-tube-to-work distance from 13 mm to 19 mm required a 15 mm/s increase in the wire feed rate for the globular-to-drop-spray transition.

Key Words: contact-tip-to-work distance (CTWD); contact tip wear; gas metal arc welding; metal transfer modes; MIL 100S-1 electrode; spray transfer.

I. INTRODUCTION

A. Gas Metal Arc Welding

Gas metal arc (GMA) welding is a process in which a consumable electrode is continuously fed into the arc. GMA welding uses the electrical arc as the heat source for melting both the base metal and the filler metal added to the weld [1,2]. An inert or slightly reactive shielding gas is used to protect the molten metal from the atmosphere. The shielding gas must have sufficient flow to displace the atmosphere from the arc as well as the weld pool until solidification occurs and the metal cools to a temperature where it does not react with the high oxygen and nitrogen levels in the atmosphere. The shielding gas also ionizes to form a high-temperature plasma which carries the current. A mixture of argon with slight additions of oxygen or carbon dioxide is generally used for low alloy steels. Typical additions to the inert gas are one to five volume percent oxygen or three to twenty-five volume percent carbon dioxide [3].

Most gas metal arc welding is performed with a constant voltage power source, which causes the arc length to be self regulating [3]. If some perturbation causes the arc length to increase, the

following steps bring the arc length into equilibrium: the circuit resistance increases; the arc current decreases; the resulting lower current melts the electrode slower than the electrode feed rate and the arc length decreases to the stable length. If some perturbation causes the arc length to decrease, the circuit resistance decreases and the system returns to a balance through the opposite sequence.

B. Metal Transfer Modes

Within the arc, the molten metal from the electrode has been observed to transfer across the arc in three distinct modes: short circuit, globular, and spray [4].

Short circuit transfer is accompanied by a cyclic extinction and reestablishment of the arc. The arc is extinguished when the electrode contacts the workpiece (short circuit), resulting in a high current flow with a low voltage. During the short circuit period, ohmic heating of the electrode occurs and continues until a length of the electrode melts. This liquid electrode column is unstable; when it separates, the arc is reestablished. This cyclic extinction of the arc may lead to severe spatter and is accompanied by a staccato sound [3]. Figure 1 is a schematic representation of short circuit metal transfer, while Figure 2 shows a typical time record of the welding current for short circuit

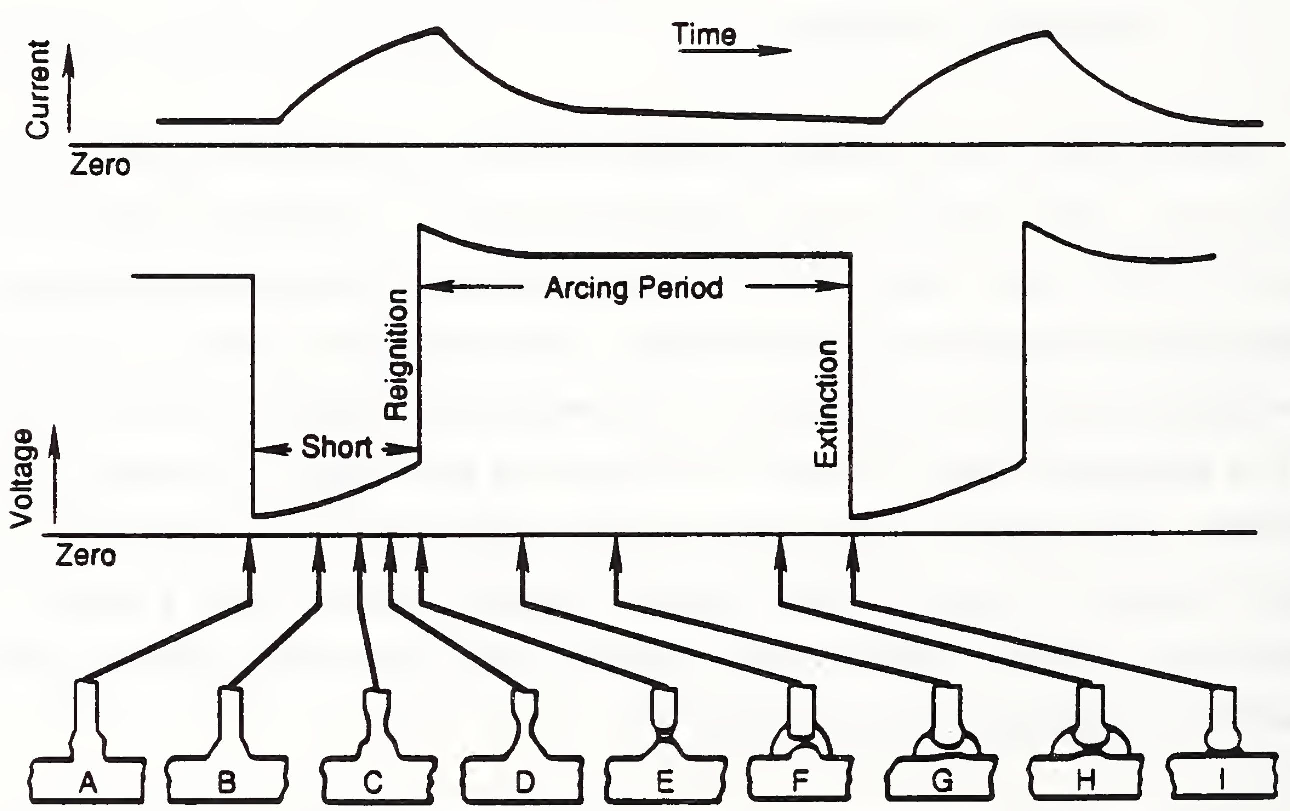

Figure 1. Schematic diagram of short circuiting metal transfer.

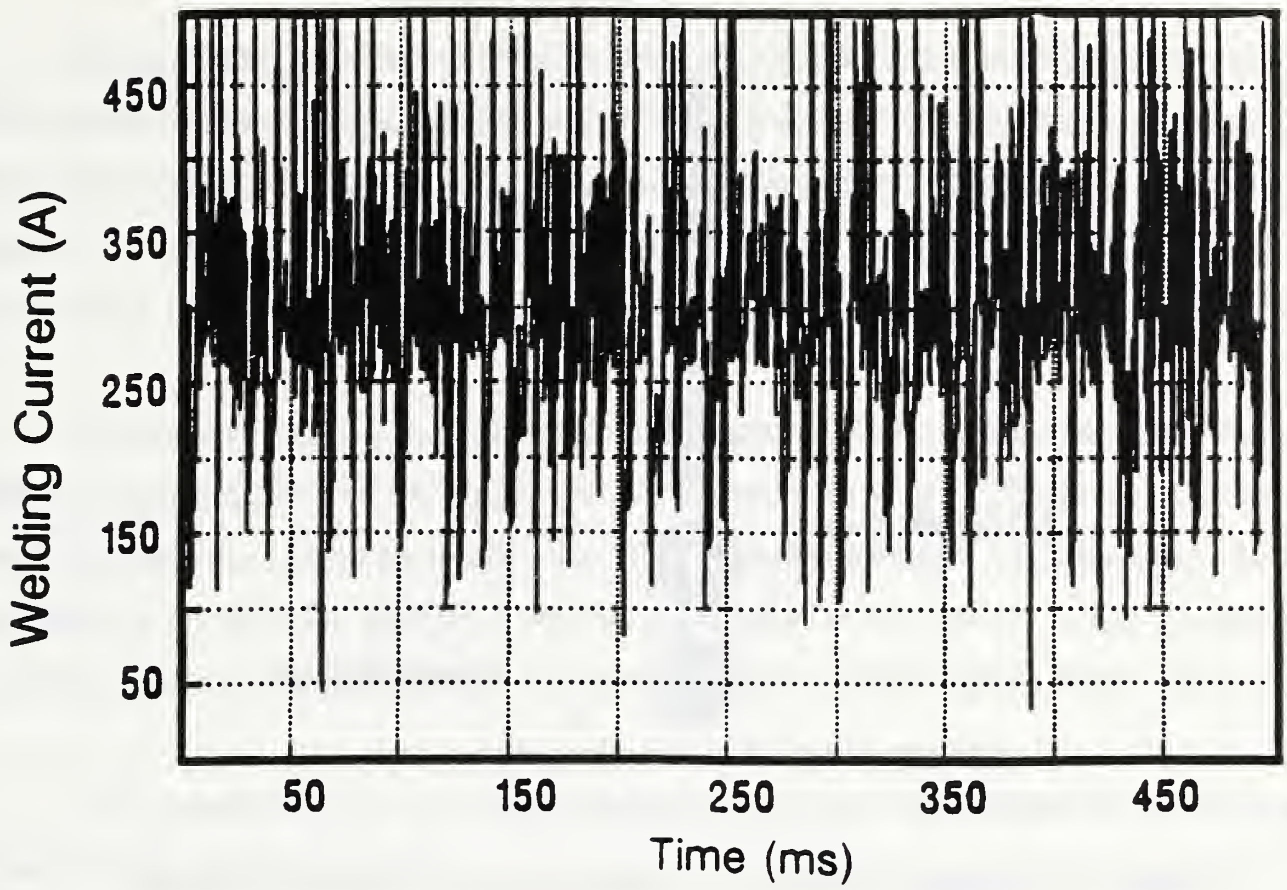

Figure 2. Typical current record for short circuit transfer.

metal transfer. Short circuit transfer mode welding is used primarily for out-of-position (non-horizontal) welding because the low power input to the base metal results in a smaller weld pool [5].

Globular metal transfer is characterized by a round globular drop of molten metal (defined as droplet diameters greater than the diameter of the electrode) forming at the electrode tip [3]. Figure 3 is a schematic diagram of the electrode tip for globular transfer. When the droplet has attained a sufficient size for gravity and the electromagnetic pinch force to overcome the surface tension, the droplet detaches and is transferred across the arc to the weld pool [3].

The higher power input of globular over short circuit transfer, and to a lesser extent the combination of pinch force, gravity, and shielding gas flow, cause globular transfer to produce a weld bead shape with a deeper penetration than short circuit transfer [3]. Although globular transfer is a steadier method of metal transfer than short circuit, it is rarely used for production welding because the weld pool is broad and the droplets may not be projected toward the pool.

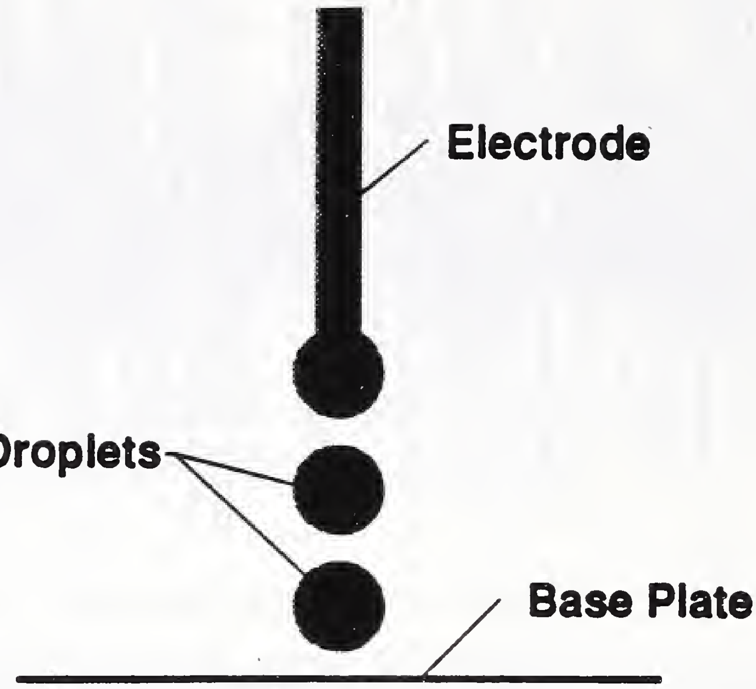

Figure 3. Schematic diagram of the electrode tip for globular transfer.

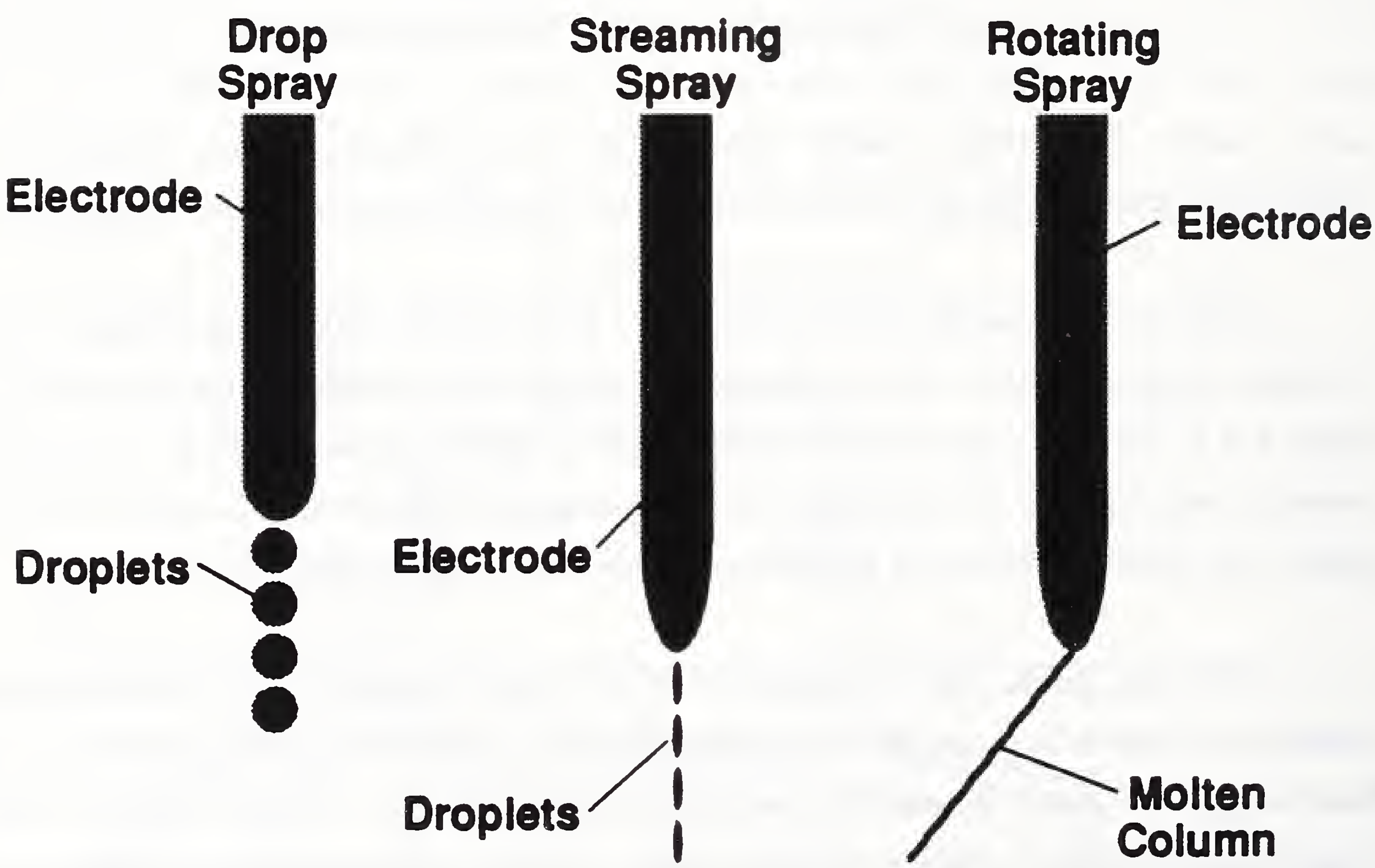

Figure 4. Schematic diagram of the electrode tip for spray transfer.

Spray transfer is characterized by smaller droplets than those observed in globular transfer. The droplet diameter is approximately that of the electrode or smaller [3]. Figure 4 is a schematic of the electrode tip during spray transfer. Droplet transfer for spray transfer is much the same as the globular transfer with the distinction between them based upon the size and, therefore, frequency of the droplets transferred.

Figure 4 shows that spray transfer is characterized by a conical electrode tip, caused by the higher current density and the larger pinch (Lorentz) force [4]. The droplets projected from the small diameter tip, are much smaller than the electrode diameter. Additionally, the initial droplet acceleration for globular transfer is approximately that due to gravity, while for spray transfer, the Lorentz force contribution is much stronger, accelerating the droplets toward the weld pool [6].

Spray metal transfer has a high deposition rate but is not suitable for out-of-position welding because of the large weld pool.

C. Spray Transfer Subclassifications

The spray transfer region can be further divided into three subclassifications: projected (drop) spray, streaming spray, and rotating spray [3]. Drop spray transfer is similar to globular transfer in that both have roughly spherical droplets of molten metal. Upon a further increase in wire feed rate and voltage, individual droplets become less distinct, and an almost continuous column of molten metal extends from the electrode to the base plate. This is named streaming-spray metal transfer. In rotating spray transfer, the electromagnetic forces have become so large that the metal in the arc column experiences forces which have large nonaxial components [6,7]. These nonaxial components cause the molten column to have an initial velocity which is at an angle to the electrode axis. The liquid metal follows a helical course from the electrode to the base plate.

D. Contact-Tube-to-Work Distance

The contact-tube-to-work distance (CTWD) affects the metal transfer mode by altering the amount of ohmic heating occurring in the electrode. The CTWD is composed of the electrode extension (distance from the contact tube to the arc) and the arc length. As the CTWD

is increased (with a constant voltage power source), the arc length shortens, causing the electrode extension to increase in accommodation. This increase in the electrode extension results in increased ohmic heating of the electrode between the contact tube and the arc.

E. Importance of Work

To offset the projected shortage of skilled welders as well as to remove humans from the uncomfortable environment near an arc, intelligent welding systems should be developed. These systems would duplicate much of the human welders' expertise and allow better overall weld quality.

The correlation of electrical signals to physical arc characteristics (through-the-arc sensing) would permit the development of an intelligent control system for welding. A through-the-arc sensing strategy does not intrude into the arc region and eliminates sensor-workpiece interference and sensor blinding. Electrical perturbations related to metal droplet transfer could be monitored and, based on those fluctuations, the controller could alter the power source output to produce a high quality weld. This system would supply the expertise of a welder which is necessary for real-time quality control.

The intelligent control system would also allow higher quality welds to be produced as well as increased productivity. It would allow a single operator to monitor multiple machines from a remote position.

II. EXPERIMENTAL PROCEDURE

This study examined in detail the spray transfer mode. The boundaries of the spray transfer mode for the different combinations of welding power source, welding gun, and electrode were established in terms of voltage and current values. The level of spatter, the audible sound of the arc, as well as a through-the-arc laser imaging system and actual visual inspection of the arc, were used to define the boundaries. A correlation of the electrical signals of the welding arc with the physical arc characteristics was sought.

Once the boundaries of the spray transfer mode were established, an investigation of the locations of the transfer mode boundaries (subclassifications) within the spray mode was conducted. To establish the boundaries of the spray transfer region, an experimental matrix covering the voltage range of 24 V to 40 V and current range from 175 A to 500 A was explored. The wire feed rates varied from 84 mm/s to 335 mm/s (3.3 in/s to 13.2 in/s).

Other variables, such as electrode composition (MIL 100S-1); shielding gas composition and flow rate (Ar-2% O_2, 0.3 L/min, respectively); and CTWD were maintained constant. Base plate thickness and travel speed of the automatic carriage as well as weld orientation were also held constant throughout each of the three CTWD portions of the investigation.

A. Equipment Description

A commercial constant potential DC arc welding power source supplied the current and voltage for the welding process. However, the power output was then regulated, filtered, and monitored by a 600 A transistorized DC welding current regulator. A manual GMA welding gun was held stationary while the plate was moved underneath, permitting a through-the-arc laser imaging system to view the tip of the electrode during welding.

A schematic diagram of the through-the-arc imaging system is presented in Figure 5. The through-the-arc imaging system consisted of a 20 mW helium-neon laser; a high speed (up to 1000 frames/s) video camera with an 90 mm, f = 3.5 lens; a mirror; two focusing lenses; a narrow band pass laser filter; and a frosted glass projection screen. A video cassette recorder/player and video monitor permitted recording and viewing of the video images. The mirror was utilized to protect the laser lens from the weld spatter. The first lens allowed the incident laser light to be focused to the size of the welding arc and electrode tip for an image of the entire region of interest. The narrow band pass filter after the welding arc transmitted only the monochromatic laser illumination, eliminating most of the light generated by the arc. The final lens focused the laser light for projection on the frosted glass screen. The frosted glass screen made the alignment of the video system less critical. The video system recorded the actual welding process in real time at high speed, and replayed it at the 30 Hz rate of conventional video, or at lower frame rates down to stop action.

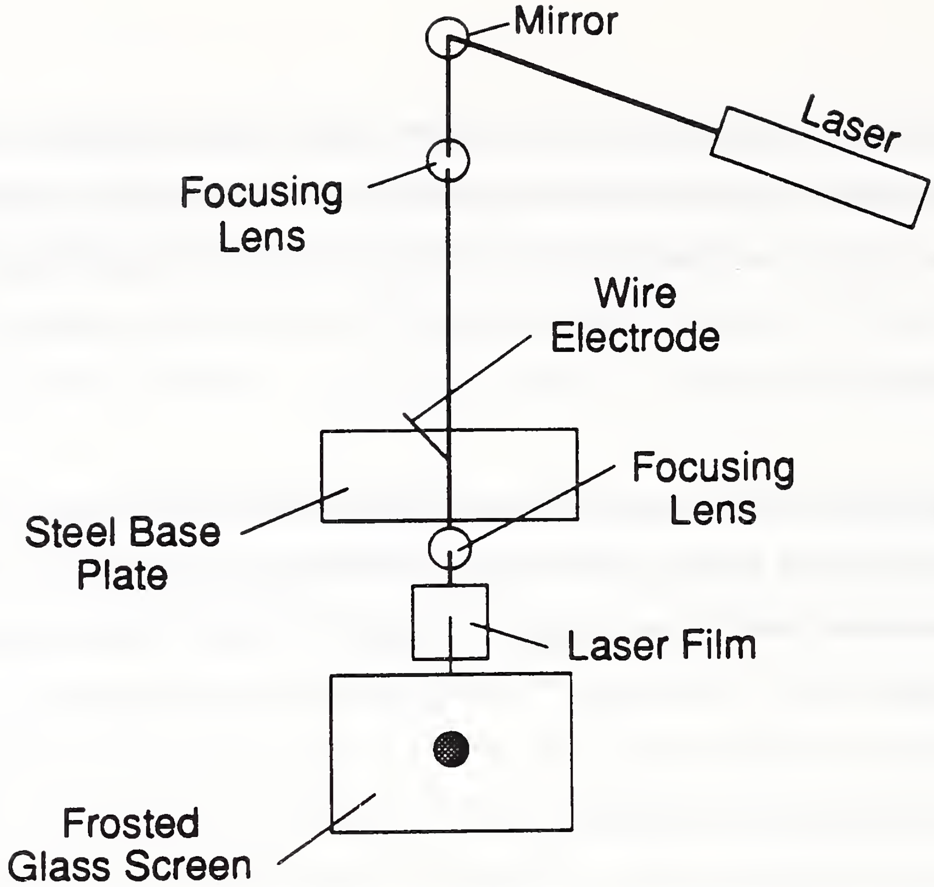

Figure 5. Schematic diagram of laser imaging system.

B. Method of Data Collection

A computer was equipped with an analog-to-digital (A/D) conversion board to sample the current and voltage values during welding. The actual current and voltage data were collected with a program (Appendix A) written with a high level programming language. The software allowed different sampling rates as defined by the user. For this study, a sampling rate of 500 Hz was selected to obtain average values of voltage and current at the different transfer modes. The actual currents and voltages (Appendix B) were correlated with a visual video image of the welding process, particularly the tip of the electrode as the metal transfer was taking place.

III. RESULTS AND DISCUSSION

A. Mean Current and Wire Feed Rate

Although these data are specific (strictly speaking) to the power source, the welding head, and the electrode, the major influence on the transfer mode is the electrode and shielding gas

compositions. Therefore, these data provide useful maps of the operating range for the electrode, for any transfer mode. Figure 6 is a map of the mean current and voltage combinations and the associated metal transfer mode, for a CTWD of 13 mm (1/2 in). The * symbols represent those welding conditions that resulted in drop spray metal transfer; □ indicates streaming spray transfer; and X indicates short circuit metal transfer. For the 13-mm CTWD, no globular or rotating spray transfer was observed. Both of these modes are associated with a longer CTWD, so their absence is not surprising with this short CTWD. The absence of rotating spray transfer at high currents encouraged us to examine this effect closely, since the spatter and wide bead associated with rotating spray often impose an upper limit to deposition rate.

Figure 7 is a map of current and voltage values for a CTWD of 19 mm (3/4 in). The symbols are the same as those used in Figure 6; in addition, + represents globular metal transfer and ▵ represents rotating spray transfer. Here, all of the transfer modes are present.

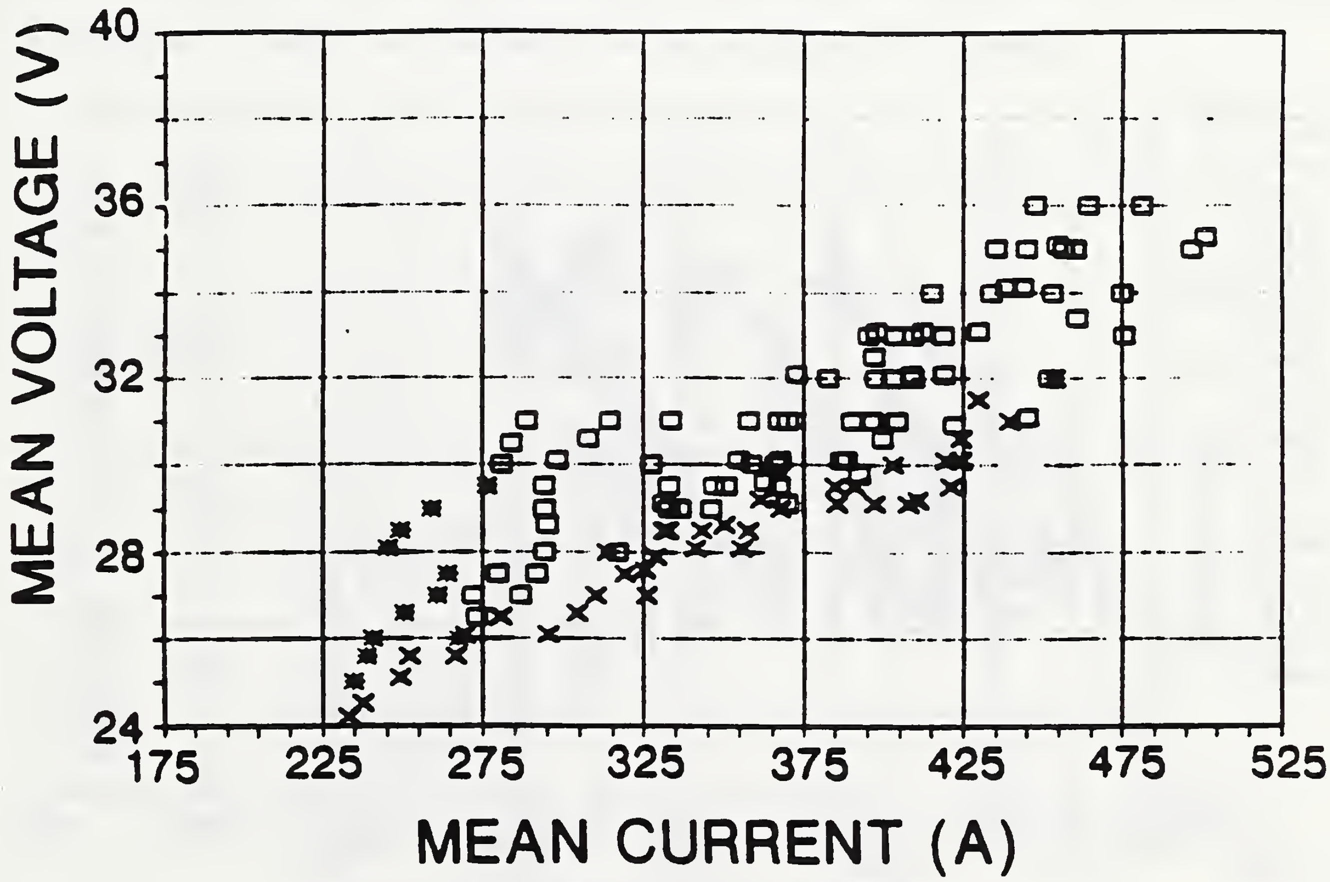

Figure 6. 13-mm contact-tube-to-work-distance: mean current versus voltage.

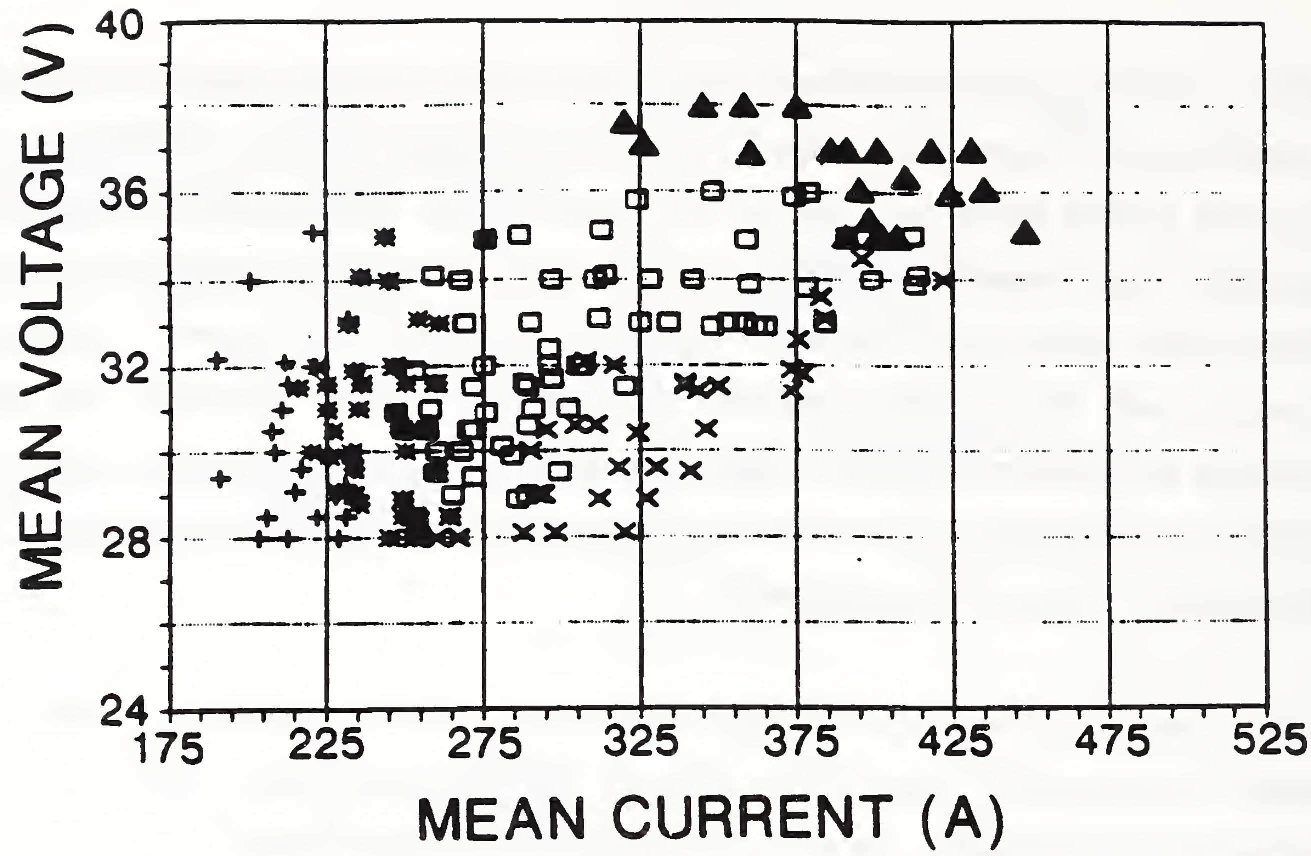

Figure 7. 19-mm contact-tube-to-work-distance: mean current versus voltage.

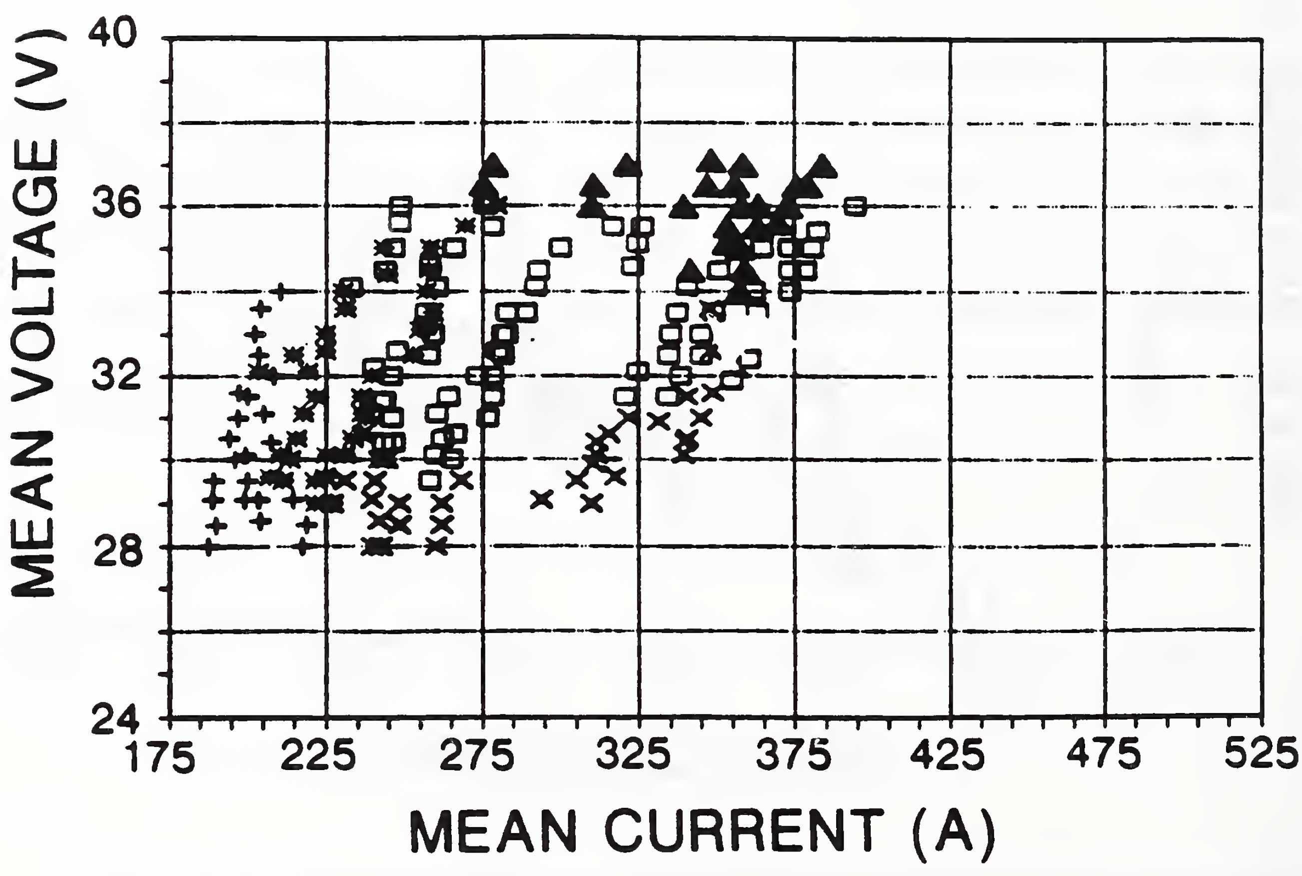

Figure 8. 25-mm contact-tube-to-work-distance: mean current versus voltage.

Figure 8 illustrates the various metal transfer modes and the associated current and voltage values for a CTWD of 25 mm (1 in). The symbols represent the same metal transfer modes as in Figure 7.

While current is often incorrectly considered to be an independent variable in GMAW, it is wire feed rate that is the truly independent variable. The wire feed rate depends only on the wire feeder control setting since the power for the wire feeder is separate from the power supplied for the welding process. The wire feed rate versus mean voltage plots for the three CTWDs are presented in Figures 9 (13 mm), 10 (19 mm), and 11 (25 mm). The symbols used to distinguish the transfer modes in Figures 9 through 11 are identical to those of Figures 6 to 8: X indicates short circuit; +, globular; *, drop spray; □, streaming spray; and ▵, rotating spray.

Figures 9 to 11 show the effect of CTWD more clearly. For example, an increase in the CTWD from 13 mm (1/2 in) to 19 mm (3/4 in) caused the globular to drop spray transition to shift from a wire feed rate of 105 mm/s to 120 mm/s at a constant voltage of 29.5 V. With a further increase of CTWD to 25 mm (1 in) the same transition shifted to 130 mm/s.

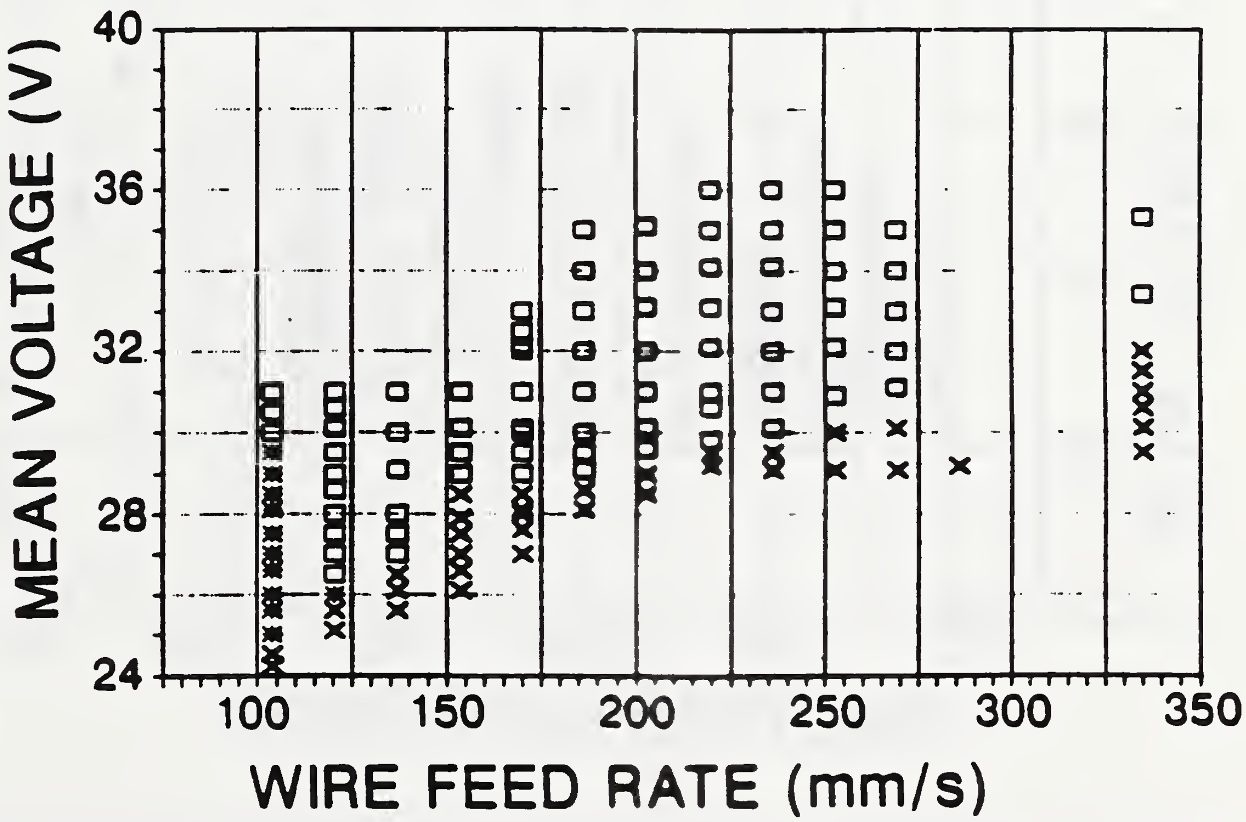

Figure 9. 13-mm contact-tube-to-work-distance: wire feed rate versus voltage.

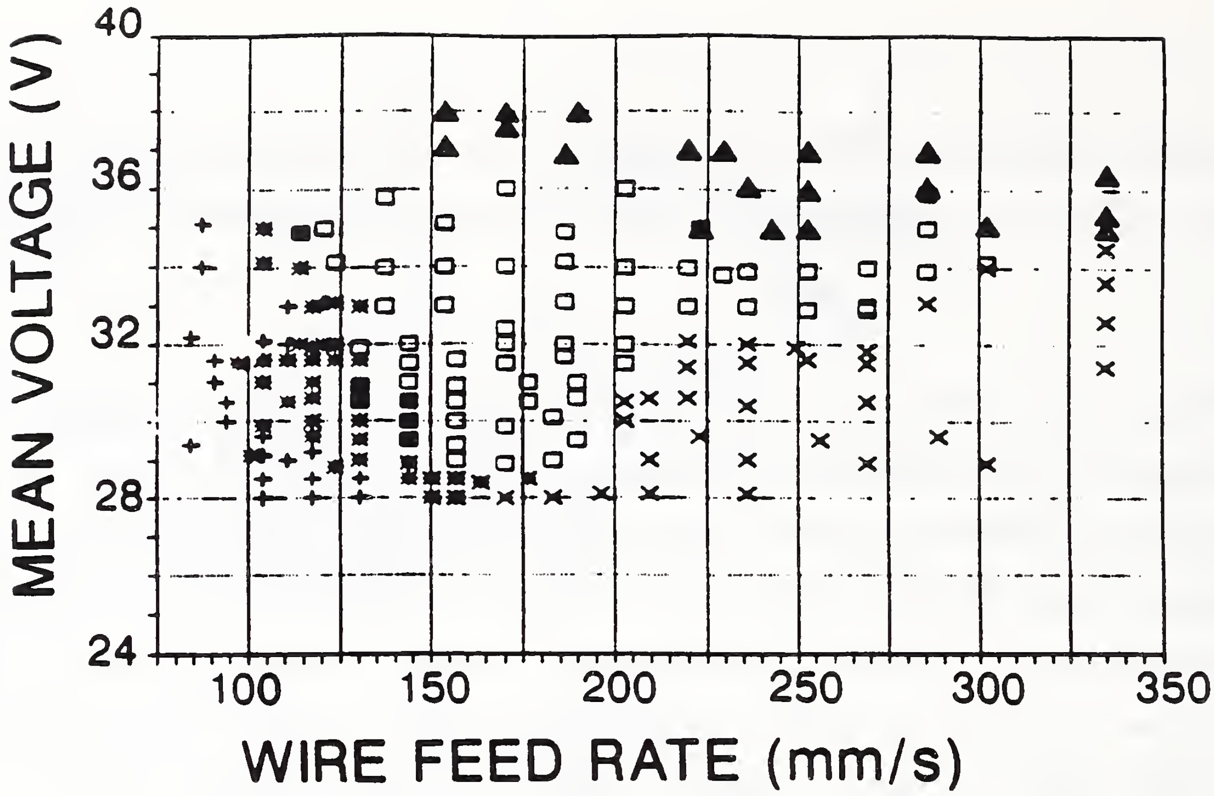

Figure 10. 19-mm contact-tube-to-work-distance: wire feed rate versus voltage.

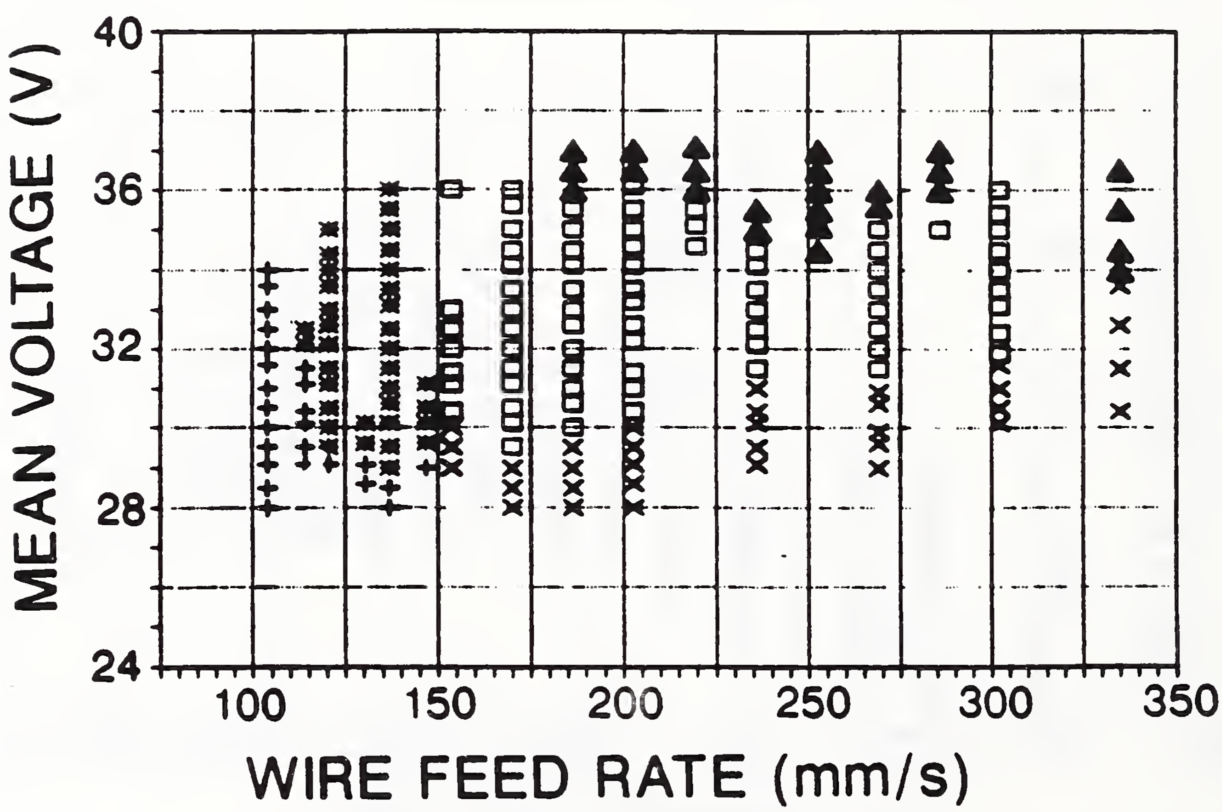

Figure 11. 25-mm Contact-tube-to-work-distance: wire feed rate versus voltage.

The shifts in the different transfer mode boundaries as a result of the CTWD changes are summarized in Figures 12 and 13. Figure 12 shows the shift of the drop spray transfer region as a result of increasing the CTWD from 13 mm to 19 mm to 25 mm. The symbol X indicates the location of the drop spray region with a 13 mm CTWD, + indicates the region for a CTWD of 19 mm, and * indicates the 25 mm CTWD. The shift was more noticeable with the CTWD change from 13 mm to 19 mm than with a CTWD change from 19 mm to 25 mm. Figure 13 illustrates the locations of the streaming spray metal transfer mode for the three different CTWDs, the symbol X represents 13 mm, + 19 mm, and * 25 mm.

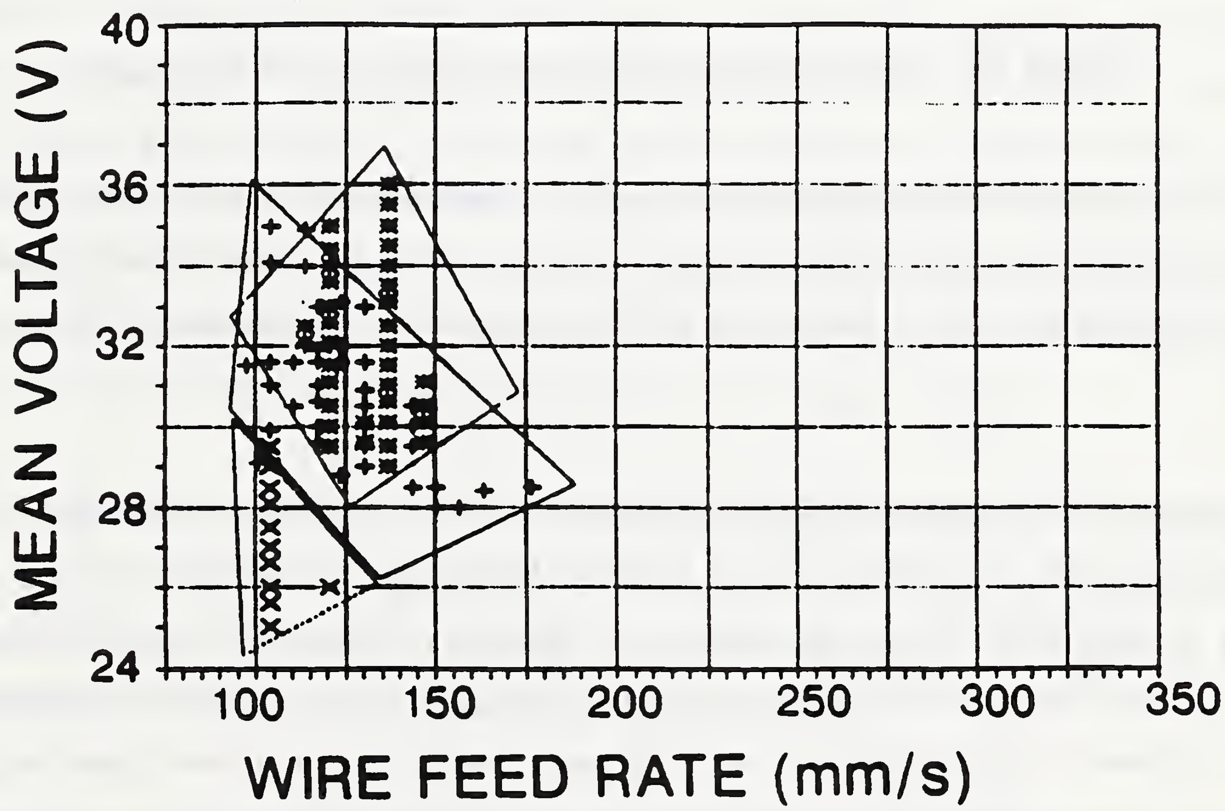

Figure 12. Shift in drop spray transfer due to contact-tube-to-work distance changes.

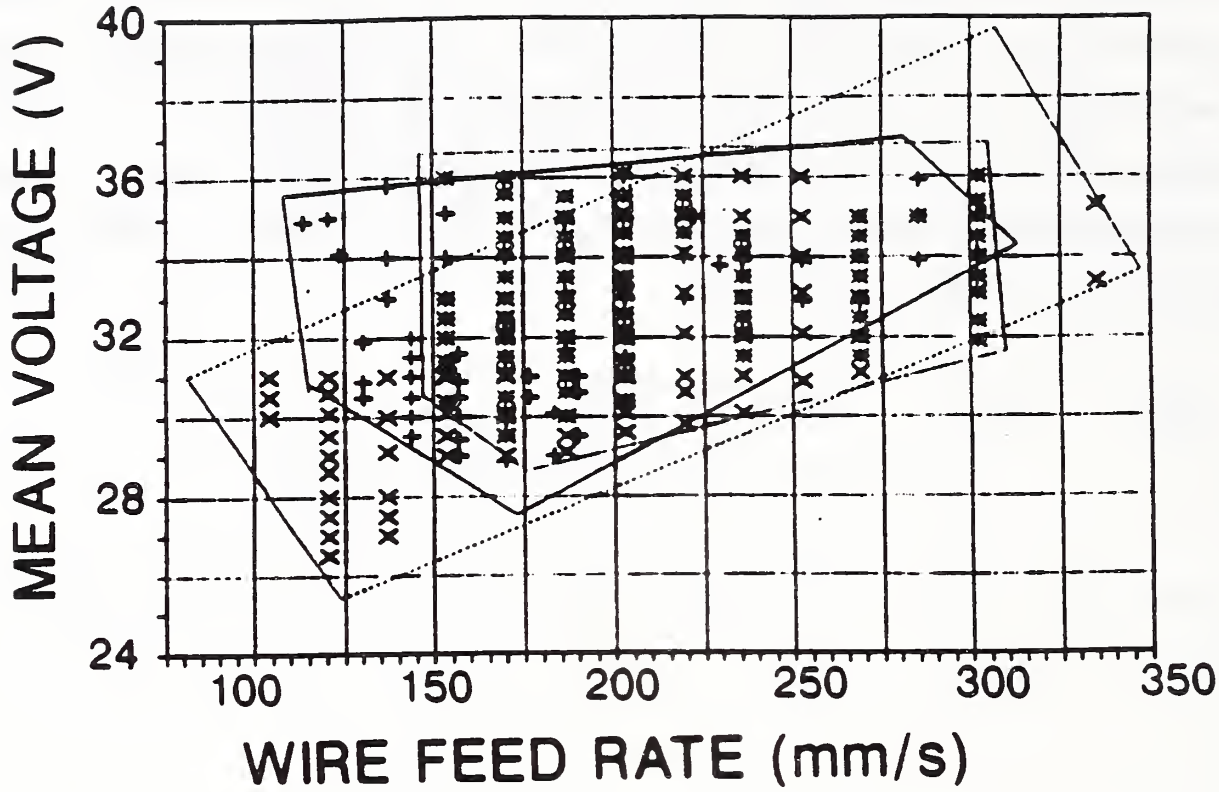

Figure 13. Shift in streaming spray transfer due to CTWD changes.

These figures illustrate the fact that the CTWD has a powerful effect on the location (current and voltage values) of the transition to drop spray or streaming spray metal transfer modes. In both figures, the beginning of the transfer mode (in both wire feed rate and voltage) increases as CTWD increases.

As the CTWD increases for a given voltage, more of the electrode extends beyond the contact tube, and the length of electrode that is carrying the current increases (the current enters the electrode at the contact tube and continues to the arc). Because the electrode has inherent resistance (which increases with length and temperature), both the resistance of the electrode and the total resistance of the circuit increase. This larger resistance causes more ohmic heating in the electrode [8], which preheats the electrode and increases the melting rate. However, the increased resistance reduces the current in the circuit and this power loss dominates the ohmic heating of the electrode. Regaining the former power requires an increase in current (wire feed rate) and/or

voltage. Thus, the transfer mode regions tend to shift to higher wire feed rate (current) and/or voltage with an increase in CTWD.

The power dissipated by a resistance is the product of the voltage across and the current through the resistance [4].

$$P = V \cdot I. \tag{1}$$

Increasing the voltage increases the power, and allows the arc length to remain constant even though the CTWD increases. At a wire feed rate of 120 mm/s with a CTWD of 13 mm, the globular to drop spray transition occurred at approximately 26 V, whereas with a 19 mm CTWD the same transition occurred just under 29 V. A further increase of CTWD to 25 mm (1 in) resulted in the transition at nearly 29.5 V.

Another example of the voltage increase necessary for the similar arc character, as a result of the CTWD increase, occurs for the short circuit to streaming spray transfer mode transition. At a constant wire feed rate of 170 mm/s, the transition occurred at 28.5 V, 29 V, and 29.5 V for 13 mm (1/2 in), 19 mm (3/4 in), and 25 mm (1 in) CTWDs, respectively. A notable shift in transfer mode also occurs at 270 mm/s and 31 V; the transfer mode is streaming for 13 mm CTWD, whereas for 19 and 25 mm CTWD, short circuit transfer is evident. The increase of CTWD from 13 mm to 19 mm increases the power loss from ohmic heating. With less power available to melt the electrode, the melting rate of the electrode must decrease. This decrease in power causes the melting rate to become less than the wire feed rate, allowing short circuit transfer to occur.

With a gradual increase in CTWD for a given voltage, the arc length becomes progressively shorter and eventually the arc extinguishes and short circuit transfer occurs. During the short circuit portion of the cycle (high current), sufficient ohmic heating occurs to melt the wire and an arc is reestablished, but insufficient power exists to maintain the arc.

At shorter CTWDs for a given voltage, streaming spray transfer remains the transfer mode to higher electrode feed rates, permitting a greater deposition rate with a stable transfer of metal.

A longer CTWD is desirable for manual welding as it allows a better view of the weld area and, therefore, the operator can react to the changing conditions of the welding process. Development of a control system for mechanized welding, which could react very quickly to changing conditions, would permit use of a shorter CTWD and, therefore, a greater metal deposition rate.

B. Current Standard Deviation

Figures 14, 15, and 16 are the welding current standard deviation isopleth plots for the three CTWDs, 13 mm, 19 mm, and 25 mm. Figure 14 is the same plot as Figure 9 with the addition of the current standard deviation isopleths for the 13 mm CTWD. The symbol * indicates drop spray metal transfer, □ indicates streaming spray transfer, and X indicates short circuit metal transfer, the same symbols as used previously. Likewise, Figures 15 and 16 are Figures 10 and 11, enhanced with the current standard deviation isopleths.

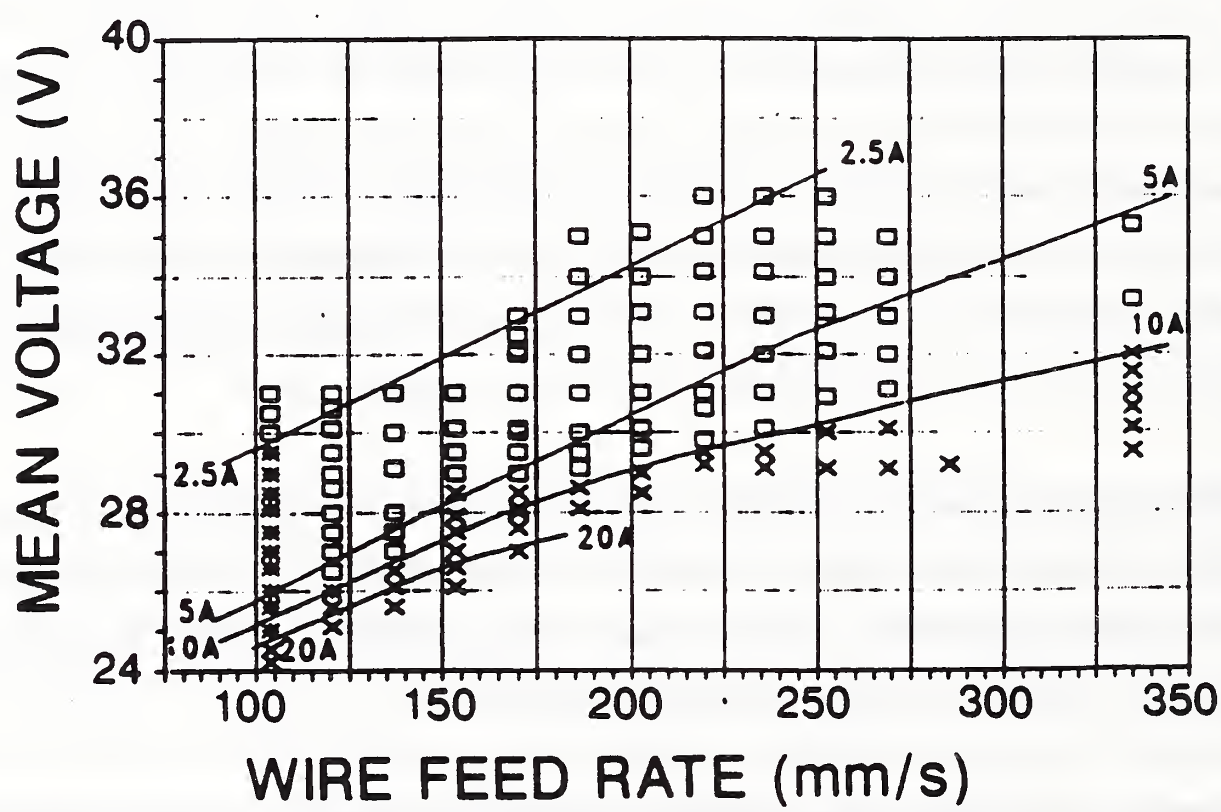

Figure 14. 13-mm current standard deviation isopleth plot.

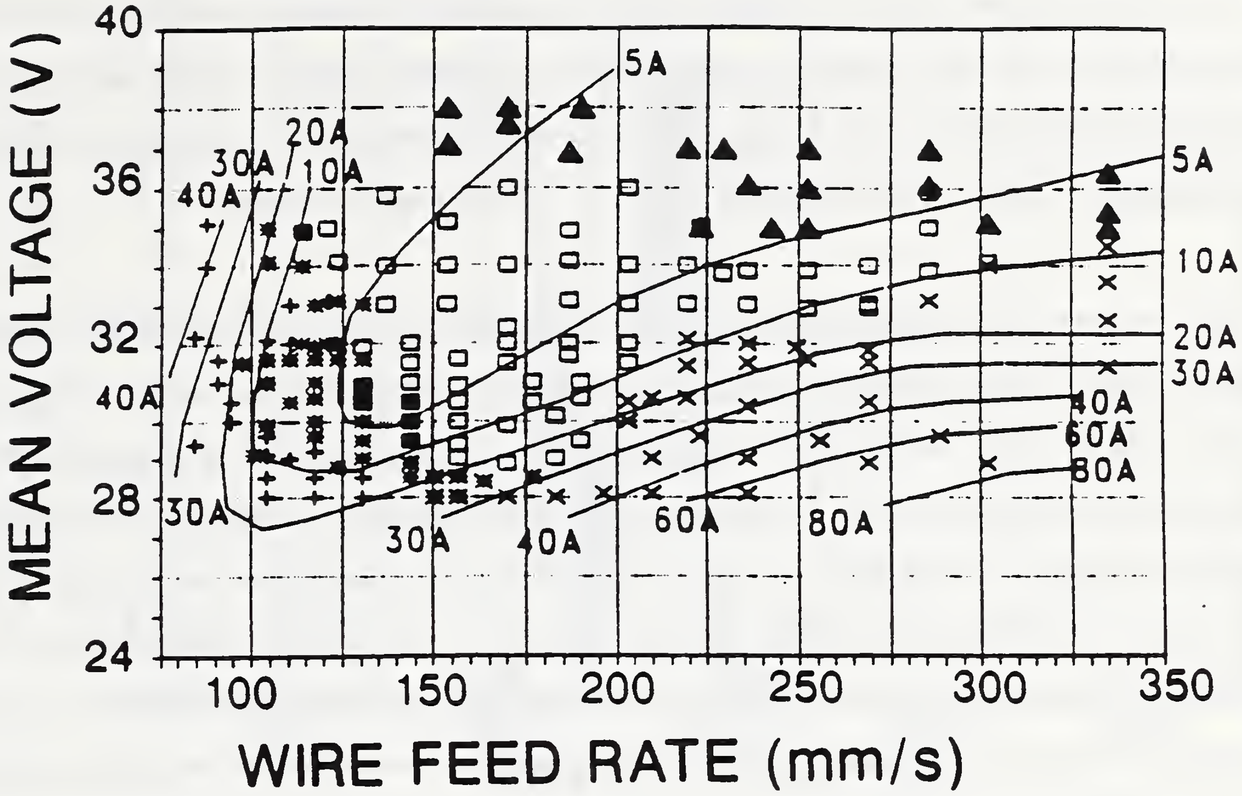

Figure 15. 19-mm current standard deviation isopleth plot.

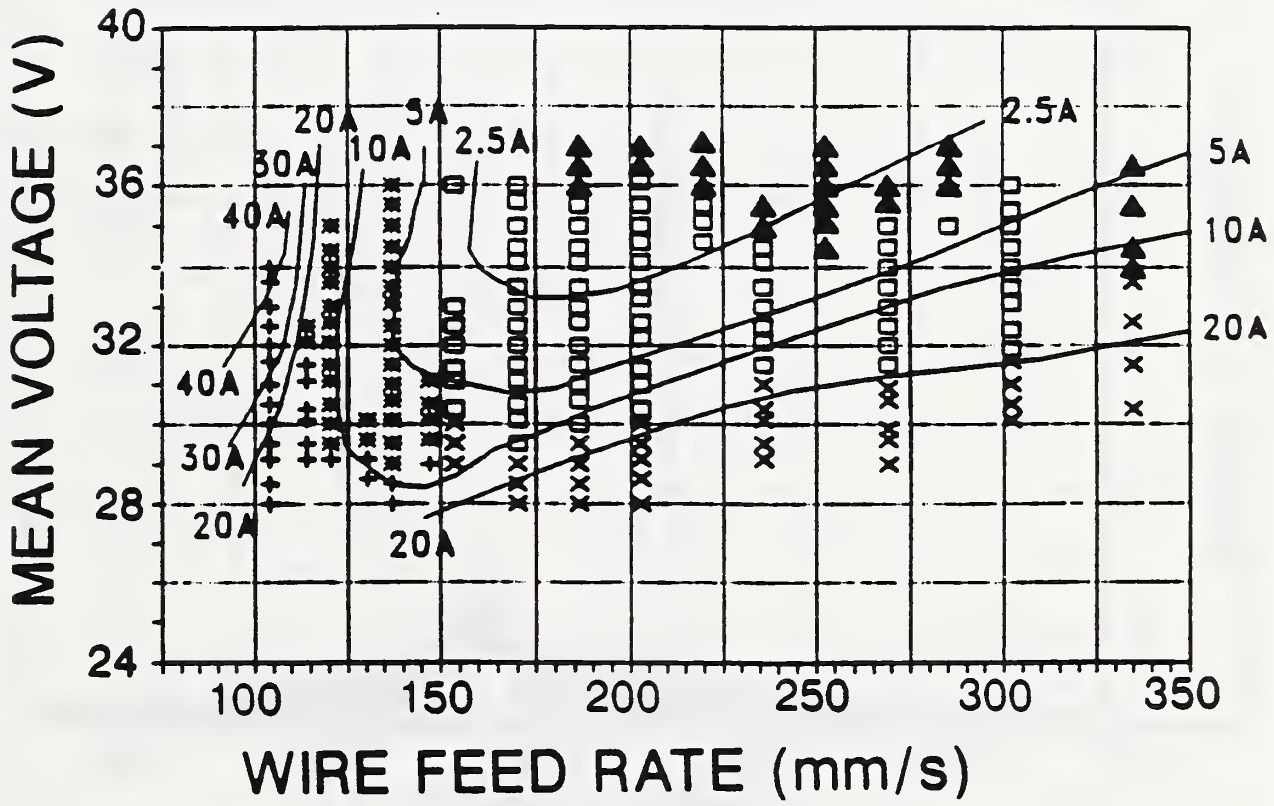

Figure 16. 25-mm current standard deviation isopleth plot.

These plots show that the highest current standard deviation occurs for the least stable transfer mode, short circuit. Globular transfer has a somewhat smaller current standard deviation. The three spray modes (drop, streaming, and rotating) all have similar magnitudes for the current standard deviation, which are the smallest values of all five transfer modes.

The source of the standard deviation in current can be found by examining a histogram for each transfer mode: short circuiting (Figure 17), globular (Figure 18), and spray (Figure 19). The short circuit transfer mode, which has the largest current standard deviation, is characterized in Figure 17 by a very wide range in current. In the weld current histogram, the highest currents occur during the actual short circuit, a broad peak centered near 290 A occur during the stable arc period, and the lowest currents occur during transitions between the two. The transfer fluctuates over this range giving an arithmetic average current which is substantially less than the maximum. In the lower voltage portion of the short circuit transfer mode region, the histogram has two peaks, one for stable arcing and one for the short circuit.

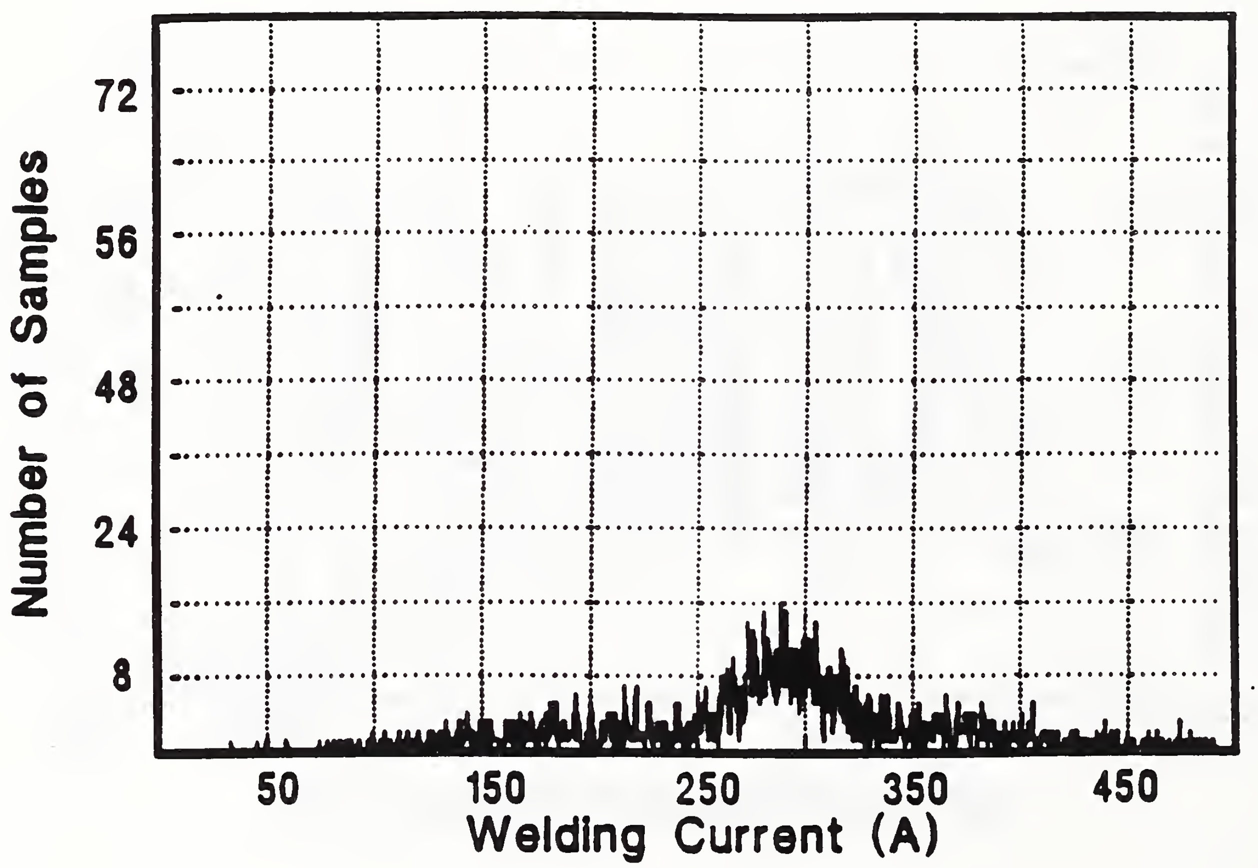

Figure 17. Typical histogram for current in short circuit transfer.

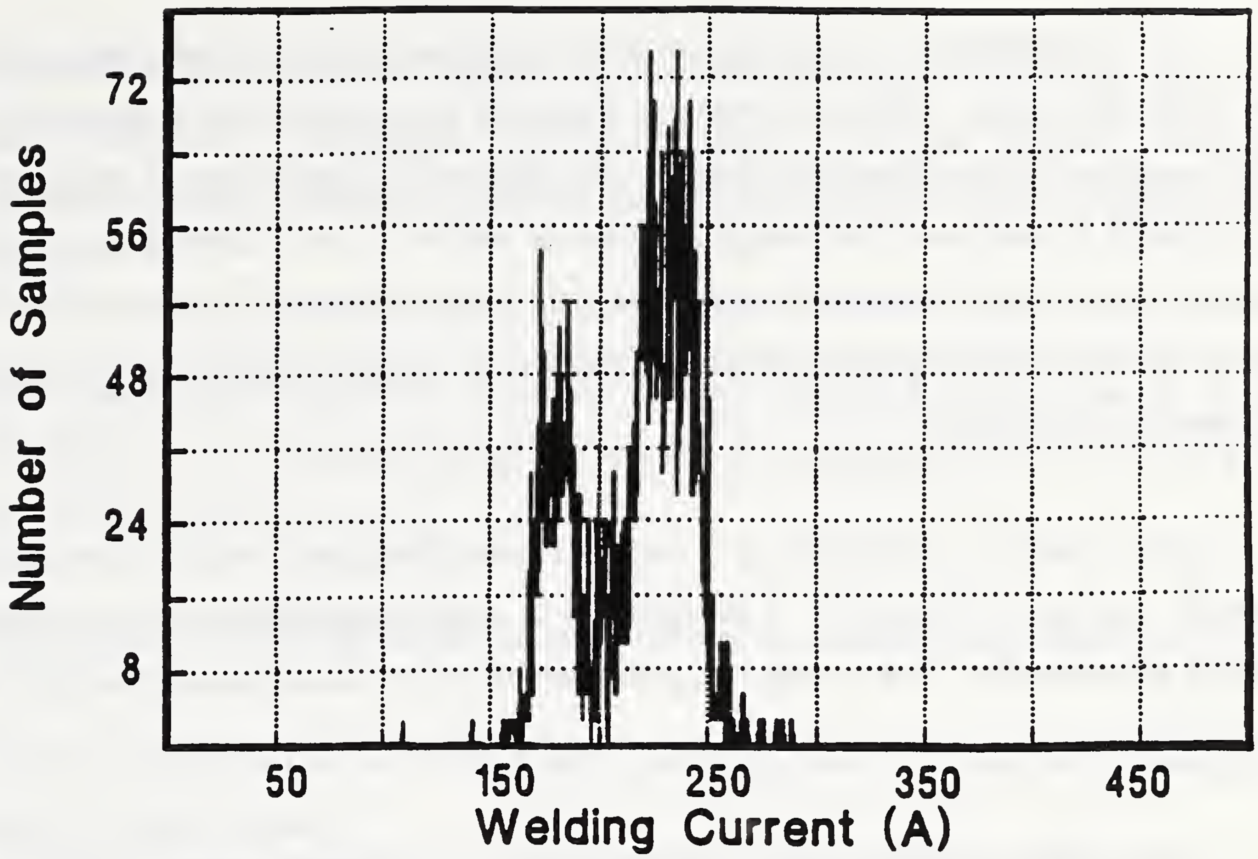

Figure 18. Typical histogram for current in globular transfer.

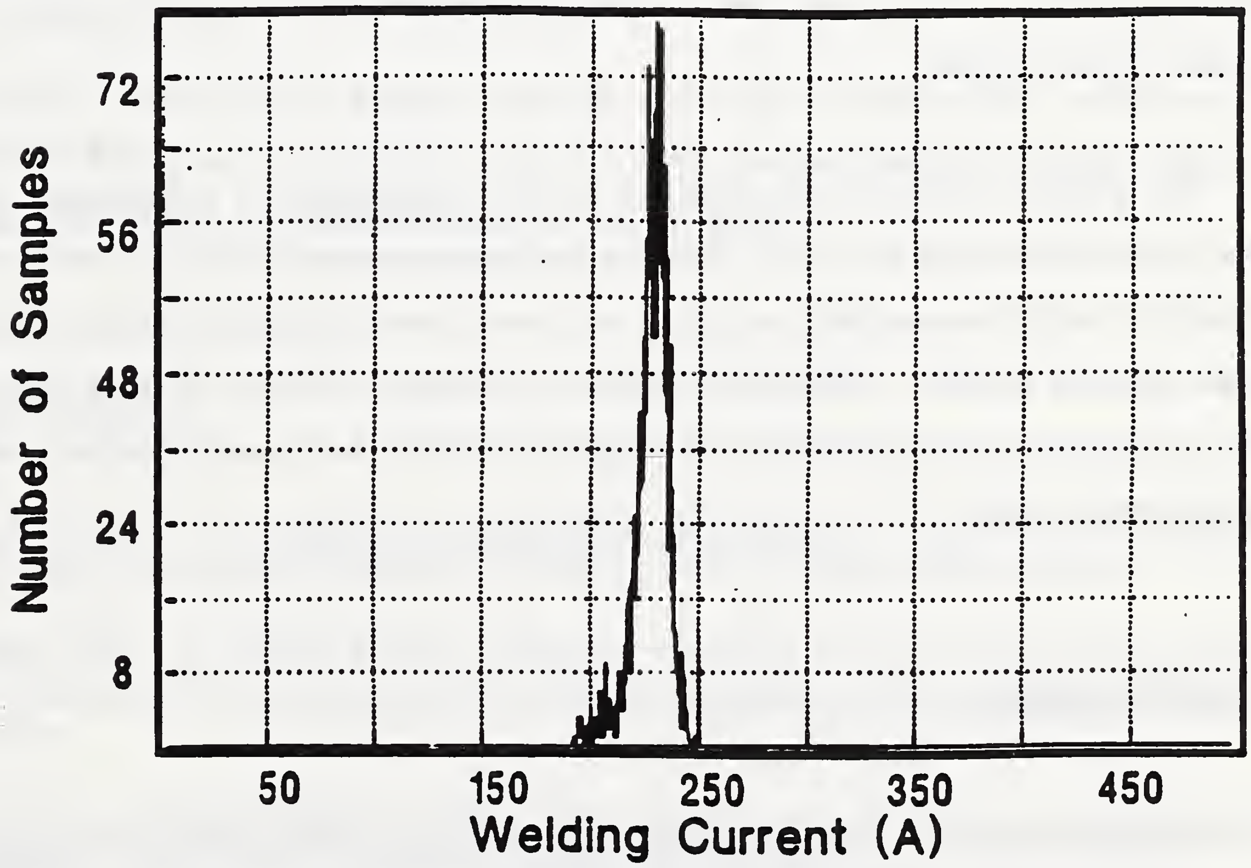

Figure 19. Typical histogram for current in spray transfer.

Globular transfer is also characterized by two distinct current ranges, closer together than for short-circuiting transfer. The two currents in Figure 18 are characteristic of globule growth and the period immediately after globule detachment. The high current peak occurs as the globule is growing, the arc length is small and the voltage drop across the arc is low. Immediately after the globule detaches, the arc length becomes longer, causing a higher voltage and a lower current. The current standard deviation for the globular transfer is smaller than that of the short circuit transfer, as shown in Figures 12, 13, and 14.

Spray transfer is evidenced by a narrow current histogram, with the two peaks becoming essentially one, as in Figure 19. The variation in current and voltage have become less upon achieving spray transfer. The current range over which the arc varies has become quite small, on the order of 25 A.

The standard deviation of the current record is a convenient measure of the transfer mode. Welds with a current standard deviation greater than 20 A (with wire feed rates greater than 200 mm/s) exhibit short circuit metal transfer. Those with current standard deviations less than 10 A exhibit spray transfer. The change from a standard deviation of 20 A to 10 A signals the transition from short circuit to spray.

The globular to drop spray transition is also characterized by a reduction in the current standard deviation from 20 A to 10 A. Welds with a current standard deviation less than 10 A exhibit spray metal transfer characteristics and those welds with current standard deviations greater than 20 A exhibit globular transfer. Although the standard deviation of current by itself cannot distinguish globular from short-circuiting transfer, the standard deviation can be used to signal a deviation from the spray transfer mode.

IV. CONCLUSIONS

1. Voltage/current or voltage/electrode feed rate maps are appropriate for reporting the response of MIL 100S-1 electrode to GMAW.

2. The standard deviation of the current is a robust indication of metal transfer mode for a MIL 100S-1 electrode. The highest standard deviation is indicative of short circuit transfer; moderate standard deviation, of globular transfer; and the lowest standard deviation, of spray transfer.

3. Spray metal transfer produces a current standard deviation of less than 10 A with the transitions to other modes indicated by the current standard deviation increasing into the range of 10 to 20 A.

4. Increasing the CTWD decreases the mean current at a constant wire feed rate and voltage.

5. Current histograms can be coupled with average current and standard deviation data to monitor transfer mode.

V. ACKNOWLEDGMENTS

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APPENDIX A
ASYST PROGRAM LISTING*

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\
\ 3 Channel Acquisition and Analysis
\       with display
\
\   ASYST names appear in CAPITOL.LETTERS
\   user names appear in  small.letters
\                                               RBM 8/90
\ ************************************************************************

15 STRING fname                    \ file name string
INTEGER SCALAR #samples/channel   \ number of samples per channel to acquire
INTEGER SCALAR #.of.samples       \ number of samples to be plotted, analyzed
REAL SCALAR sample.frequency      \ sampling frequency per channel
INTEGER SCALAR #.of.channels      \ number of channels to be sampled
                             \ total sample frequency
                             \ = sample.frequency * #.of.channels
INTEGER SCALAR a/d.resolution     \ resolution of A/D converter
     \ #samples/channel * #.of.channels <= 32768
   4096 #samples/channel :=    \ define number of samples per channel
   3 #.of.channels :=          \ define number of channels to sample
   4096 a/d.resolution :=      \ define a/d resolution

REAL DIM[ 10 ] ARRAY file.info    \ array to hold info to be written to disk
INTEGER DIM[ #samples/channel , #.of.channels ] ARRAY data.buffer

INTEGER SCALAR channel.no                  \ active channel number

REAL SCALAR gpr                         \ general purpose real
INTEGER SCALAR gpi                        \ general purpose integer

DIM[ 100 ] ARRAY display.buffer   \ arrays for real-time data holding
REAL DIM[ 5000 ] ARRAY gpra            \ and displaying
REAL DIM[ 1500 ] ARRAY c2.buf            \ and displaying
REAL DIM[ 1500 ] ARRAY c3.buf            \ and displaying
```

*ASYST is the trade name of the programming language; no endorsement or criticism is implied. Other products may work as well or better.

```
 0 0 24 18 WINDOW {live}              \ window definition for live plots
 0 0 1 79 WINDOW gw                   \ window definition for static plots
\ 0 0 10 79 WINDOW gw                   \ plot debug window

 RTI-800/815                  \ initialize primitive acquisition hardware and software
 0 0 A/D.TEMPLATE channel.0      \ a/d template
 0 1 A/D.TEMPLATE channel.01      \ a/d template
 0 2 A/D.TEMPLATE channel.02      \ a/d template
\ 0 3 A/D.TEMPLATE channel.01      \ a/d template
 0 4 A/D.TEMPLATE channel.04      \ a/d template
 1 1 A/D.TEMPLATE channel.1      \ a/d template
 2 2 A/D.TEMPLATE channel.2      \ a/d template
 3 3 A/D.TEMPLATE channel.3      \ a/d template
 4 4 A/D.TEMPLATE channel.4      \ a/d template

\ ******************************************************************
\
\  : set.defaults
\
\  sets default values for system parameters
\  note that several other parameters are assigned values above
\  coordinate parameter values between here and there
\
\ ******************************************************************
: set.defaults
  -1 1 FIX.FORMAT          \ limit floating point display to 1 decimal place
  " NONAME " fname ":=       \ default file name
  1000 sample.frequency :=   \ define sample frequency per channel in Hz
  channel.0             \ default a/d template
  sample.frequency #.of.channels * 1000 / INV  \ default sampling frequency
  CONVERSION.DELAY         \ set it (sample frequency = 1/conversion.delay)
  A/D.INIT              \ initialize hardware     ( in ms ^ ^     )
;
\ ******************************************************************
\ data.to.screen
\
\ acquires one channel of data and displays it on the screen
\ used to allow user to look at data in real-time before
\ command issued to collect a buffer full to disk
\ once called, waits until a key is hit, stops and returns
\ to calling function
\
\ ******************************************************************
VUPORT  c1
  .25 .8  VUPORT.ORIG              \ set graphics window location and size
  1. .19 VUPORT.SIZE
  .05 .05  AXIS.ORIG
  .95  .9  AXIS.SIZE
```

```
VUPORT  c2
   .25 .60  VUPORT.ORIG                    \ set graphics window location and size
   1. .19 VUPORT.SIZE
   .05 .05   AXIS.ORIG
   .95  .9  AXIS.SIZE
VUPORT  c3
   .25 .40  VUPORT.ORIG                    \ set graphics window location and size
   1. .19 VUPORT.SIZE
   .05 .05   AXIS.ORIG
   .95  .9  AXIS.SIZE

: data.to.screen
  ." data to screen "          \ display what going on
   GRAPHICS.DISPLAY            \ prep graphics
   {live}                   \ set text window
   SCREEN.CLEAR                \ clear screen
   CR ." THE ACTIVE FILE"
   CR ."  NAME IS : " fname "TYPE  \ display active file name
   CR CR ." Hit any key to
   CR ." start acquisition "  \ prompt user

   c1
   HORIZONTAL NO.LABELS                \ no horizontal labels
   VERTICAL 0 2 LABEL.POINTS
   NORMAL.COORDS .5 .5 AXIS.POINT
   HORIZONTAL 0. 100. WORLD.SET          \ set range of data, must coordinate with
   VERTICAL  -5. 5. WORLD.SET           \ a/d scaling, see defaults
   OUTLINE
   XY.AXIS.PLOT
   .01 .01 POSITION " Current" LABEL

   c2
   HORIZONTAL NO.LABELS                \ no horizontal labels
   VERTICAL 0 2 LABEL.POINTS
   NORMAL.COORDS .5 .5 AXIS.POINT
   HORIZONTAL 0. 100. WORLD.SET          \ set range of data, must coordinate with
   VERTICAL  -5. 5. WORLD.SET           \ a/d scaling, see defaults
   OUTLINE
   XY.AXIS.PLOT
   .01 .01 POSITION " Light" LABEL

   c3
   HORIZONTAL NO.LABELS                \ no horizontal labels
   VERTICAL 0 2 LABEL.POINTS
   NORMAL.COORDS .5 .5 AXIS.POINT
   HORIZONTAL 0. 100. WORLD.SET          \ set range of data, must coordinate with
   VERTICAL  -5. 5. WORLD.SET           \ a/d scaling, see defaults
   OUTLINE
```

```
XY.AXIS.PLOT
.01 .01 POSITION " Field Probe" LABEL


gpra LINE.BUFFER.ON
c2.buf LINE.BUFFER.ON
c3.buf LINE.BUFFER.ON

RTI-800/815

sample.frequency #.of.channels * 1000 / INV  \ set sampling frequency
CONVERSION.DELAY

BEGIN                            \ display data, loop until key is hit
  c1
  gpra LINE.BUFFER.SWITCH
  ERASE.LINES
  channel.0
  display.buffer TEMPLATE.BUFFER
  100 TEMPLATE.REPEAT
  A/D.INIT
  A/D.IN>ARRAY
  display.buffer
  -5. 5.  A/D.SCALE
  DP>SP
  Y.DATA.PLOT

  c2
  c2.buf LINE.BUFFER.SWITCH
  ERASE.LINES
  channel.1
  display.buffer TEMPLATE.BUFFER
  100 TEMPLATE.REPEAT
  A/D.INIT
  A/D.IN>ARRAY
  display.buffer
  -5. 5.  A/D.SCALE
  DP>SP
  Y.DATA.PLOT

  c3
  c3.buf LINE.BUFFER.SWITCH
  ERASE.LINES
  channel.2
  display.buffer TEMPLATE.BUFFER
  100 TEMPLATE.REPEAT
  A/D.INIT
  A/D.IN>ARRAY
```

```
    display.buffer
    -5. 5.  A/D.SCALE
    DP>SP
    Y.DATA.PLOT


  ?KEY UNTIL  KEY                          \ key hit?
  channel.0                           \ yes, stop present acquisition
  A/D.INIT
  LINE.BUFFER.OFF   \ clean up
  AXIS.DEFAULTS
  SCREEN.CLEAR
  NORMAL.DISPLAY
  STACK.CLEAR
  CR ." Started acquisition to disk"
  CR
;
\ ********************************************************************
\
\
\ ********************************************************************
: write.to.disk
 CR ." Writing to disk "
 LOAD.OVERLAY d:\DATAFILE.SOV
  FILE.TEMPLATE
   4 COMMENTS
   data.buffer []FORM.SUBFILE
   file.info []FORM.SUBFILE
  END
  fname DEFER> FILE.CREATE
  fname DEFER> FILE.OPEN
  " line1 "
  1 >COMMENT
  " line2 "
  2 >COMMENT
  " line3 "
  3 >COMMENT
  " line4 "
  4 >COMMENT
  1 SUBFILE data.buffer ARRAY>FILE
  ?CONVERSION.DELAY file.info [ 1 ] :=
  2 SUBFILE file.info ARRAY>FILE
  FILE.CLOSE
  STACK.CLEAR
  RELEASE.OVERLAY
;
\ ********************************************************************
\
```

```
\
\ ********************************************************************
: acquire.disk
  CR ." Reading from disk "
  LOAD.OVERLAY d:\DATAFILE.SOV
   fname DEFER> FILE.OPEN
   1 SUBFILE
   data.buffer FILE>ARRAY
   2 SUBFILE
   file.info FILE>ARRAY
   file.info [ 1 ] CONVERSION.DELAY
   channel.02
   A/D.INIT
   file.info [ 1 ] INV 1000 * #.of.channels / sample.frequency :=
   FILE.CLOSE
   RELEASE.OVERLAY
   STACK.CLEAR
;
\ ********************************************************************
\
\
\ ********************************************************************
: wait.for.CR
   BEGIN
    #INPUT
   WHILE
     0 =
   REPEAT
;
\ ********************************************************************
\ plotter
\
\ completes x-y plot of arrays on top of stack
\ takes labels for axes from top of symbol stack
\ on both stacks y on top of x
\ ********************************************************************
: plotter
   GRAPHICS.DISPLAY              \ set graphics mode
   SCREEN.CLEAR                  \ clear screen
   gw                       \ set text window
   0 0 VUPORT.ORIG               \ set graph window location and size
   1 .925 VUPORT.SIZE
   .15 .15   AXIS.ORIG
   .8  .8  AXIS.SIZE
   XY.AUTO.PLOT                  \ plot two arrays on top of stack
   NORMAL.COORDS                    \ within reference of screen

      \ calculate where to start y label, get length of string, divide by
```

```
      \ 50(characters/tenth of screen height, divide by 2 to center,
      \ subtract from center (0.5) put x location on and swap
   "LEN 1. * 50. / 2. / 0.5 SWAP - 0.02 SWAP
   90 LABEL.DIR                    \ with label and character orientation
   90 CHAR.DIR                     \ at 90 degrees
   POSITION CURSOR.OFF LABEL       \ write y label
   0 LABEL.DIR                     \ with character and label
   0 CHAR.DIR                      \ direction of 0
   0.5 0.05 POSITION  LABEL        \ locate where to start x label
   .05 .05 READOUT>POSITION        \ locate readout for array.read.out
   WORLD.COORDS                    \ back to coordinates within graph

      \ display active file name and available actions
   CR CR ." File: " fname "TYPE
        ."  Sampling Frequency = " sample.frequency . ." Hz "
\        ."  V avg = " voltage mean .
\        ."  I avg = " current mean .

   CR ." 1-Dump to Printer 2-Array.Readout 3-Return   Select a key -> "
   KEY
   CASE                            \ get key and decide what to do

    49 OF CR CR  \ screen dump
        "TYPE  ."    File: "  fname "TYPE CR
        ."   Sampling Frequency = " sample.frequency . ." Hz "
\        ."  V avg = " voltage mean .
\        ."  I avg = " current mean .
         SCREEN.PRINT
      ENDOF

    50 OF ARRAY.READOUT  \ CR CR   \ array.readout function
      \ ." Active Keys -> Arrows, Home, PgUp, Ins, End, PgDn     CR to quit "
        wait.for.CR            \ loop until down
      ENDOF
                          \ otherwise just leave
   ENDCASE
;
\ ***********************************************************************
\
\
\ ***********************************************************************
: time.trace
   CR CR ." Enter Channel Number  1 Current "
     CR ."                        2 Light   "
     CR ."                        3 Field Probe  -> " #INPUT channel.no :=
   STACK.CLEAR
    CR CR ." Plot how Many Data Points, Up to " #samples/channel .
   ."  ? -> " #INPUT #.of.samples :=
```

```
  " Time Trace"
  channel.no
  CASE
   1 OF " Current "
     ENDOF
   2 OF " Light "
     ENDOF
   3 OF " Field Probe "
     ENDOF
   ENDCASE
  #.of.samples RAMP   \ create x axis time array
  ?conversion.delay  #.of.channels * * DP>SP
   data.buffer xsect[ ! , channel.no ] SUB[ 0 , #.of.samples ] -5. 5. a/d.scale
   DP>SP
      " Time (ms) "
  plotter
;
\ ******************************************************************
\
\
\ ******************************************************************
: time.amplitude.histogram
  CR CR ." Enter Channel Number  1 Current "
     CR ."                       2 Light   "
     CR ."                       3 Field Probe"
     CR ."                       4 Wire Speed "
     CR ."                       5 Voltage      -> " #INPUT channel.no :=

  STACK.CLEAR
  CR CR ." ********  Calculating Histogram *********  "
  " Histogram "
  " Number of Samples "
   0 gpra :=                     \ zero a/d count array
       #samples/channel 1 + 1
       DO
         data.buffer xsect[ I , channel.no ]         \ put Ith voltage sample on stack
    2049 +  \ get it between 1 and 4096
\          0. = IF 1 ELSE data.buffer xsect[ I , channel.no ]  THEN
         \ if zero, make it one, array index starts at 1 not 0
         gpi :=                  \ set general purpose scalar equal to it
         gpra [ gpi ]      \ put corresponding a/d.count value on stack
         1 + gpra [ gpi ] :=       \ increment that count value
      LOOP
      STACK.CLEAR
      gpra SUB[ 1 , a/d.resolution ] FIX
\       -5. 5.  A/D.SCALE
      DP>SP
      INDEX.ARRAY FIX
```

```
      SWAP
   channel.no
   CASE
    1 OF " Current "
      ENDOF
    2 OF " Light "
      ENDOF
    3 OF " Field Probe "
      ENDOF
    ENDCASE
   plotter
;
\ **********************************************************************
\
\
\ **********************************************************************
: channel.vs.channel
  STACK.CLEAR
  " Channel Vs Channel"  \ graph title
   CR CR ." Enter Y-axis Channel Number  1 Current "
     CR ."                          2 Light   "
     CR ."                          3 Field Probe  -> " #INPUT channel.no :=

?DROP  \ #INPUT leaves t/f on symbol stack, drop it
data.buffer xsect[ ! , channel.no ]
SUB[ 0 , #samples/channel 2 / ]
-5. 5. A/D.SCALE
DP>SP
 channel.no
  CASE
   1 OF " Current"
     ENDOF
   2 OF " Light"
     ENDOF
   3 OF " Field Probe"
     ENDOF
   ENDCASE

  CR CR ." Enter X-axis Channel Number  1 Current "
     CR ."                          2 Light   "
     CR ."                          3 Field Probe  -> " #INPUT channel.no :=

?DROP  \ #INPUT leaves t/f on symbol stack, drop it

data.buffer xsect[ ! , channel.no ]
SUB[ 0 , #samples/channel 2 / ]
-5. 5. A/D.SCALE
DP>SP
```

```
channel.no
 CASE
  1 OF " Current"
   ENDOF
  2 OF " Light"
   ENDOF
  3 OF " Field Probe"
   ENDOF
  ENDCASE
 VERTICAL 0 5 WORLD.SET
 DOTTED
 GRAPHICS.DISPLAY              \ set graphics mode
 SCREEN.CLEAR                  \ clear screen
 gw                            \ set text window
 0 0 VUPORT.ORIG               \ set graph window location and size
 1 .925 VUPORT.SIZE
 .15 .15   AXIS.ORIG
 .8  .8  AXIS.SIZE
 VERTICAL 0 5 WORLD.SET
 HORIZONTAL 0 5 WORLD.SET
 XY.AXIS.PLOT                  \ plot two arrays on top of stack
 XY.DATA.PLOT
 NORMAL.COORDS                 \ within reference of screen

   \ calculate where to start y label, get length of string, divide by
   \ 50(characters/tenth of screen height, divide by 2 to center,
   \ subtract from center (0.5) put x location on and swap
 "LEN 1. * 50. / 2. / 0.5 SWAP - 0.02 SWAP
 90 LABEL.DIR                  \ with label and character orientation
 90 CHAR.DIR                   \ at 90 degrees
 POSITION CURSOR.OFF LABEL     \ write y label
 0 LABEL.DIR                   \ with character and label
 0 CHAR.DIR                    \ direction of 0
 0.5 0.05 POSITION  LABEL      \ locate where to start x label
 .05 .05 READOUT>POSITION      \ locate readout for array.read.out
 WORLD.COORDS                  \ back to coordinates within graph

   \ display active file name and available actions
 CR CR ." File: " fname "TYPE
      ."  Sampling Frequency = " sample.frequency . ." Hz "
\      ."  V avg = " voltage mean .
\      ."  I avg = " current mean .

 CR ." 1-Dump to Printer 2-Array.Readout 3-Return   Select a key -> "
 KEY
 CASE                          \ get key and decide what to do

  49 OF CR CR  \ screen dump
```

```
        "TYPE ."    File: " fname "TYPE CR
        ."  Sampling Frequency = " sample.frequency . ." Hz "
\       ."  V avg = " voltage mean .
\       ."  I avg = " current mean .
        SCREEN.PRINT
     ENDOF

   50 OF ARRAY.READOUT  \ CR CR   \ array.readout function
      \ ." Active Keys -> Arrows, Home, PgUp, Ins, End, PgDn     CR to quit "
        wait.for.CR             \ loop until down
     ENDOF
                           \ otherwise just leave
  ENDCASE

  SOLID
;
\ ******************************************************************
\
\
\ ******************************************************************
: name.file
  CR CR ." Type Active File Name ->  " "INPUT fname ":=
;
\ ******************************************************************
\
\
\ ******************************************************************
: set.frequency
  CR CR ." Enter sampling frequency per channel in Hz -> "
  #INPUT sample.frequency :=
  sample.frequency #.of.channels * 1000 / INV
  CONVERSION.DELAY
;
\ ******************************************************************
\
\
\ ******************************************************************
: acquire.live
   STACK.CLEAR
   channel.02
   sample.frequency #.of.channels * 1000 / INV
   CONVERSION.DELAY
   data.buffer TEMPLATE.BUFFER
   A/D.INIT
   channel.02
   #samples/channel TEMPLATE.REPEAT
   A/D.INIT
   A/D.IN>ARRAY
```

```
  write.to.disk
;
\ *********************************************************************
\
\
\ *********************************************************************
: smooth.data
  STACK.CLEAR
  CR CR ." Enter Cutoff Frequency in Cycles/Point (0.03 - 0.5) " #INPUT
  CR ."     *******  SMOOTHING   ******* "
  LOAD.OVERLAY WAVEOPS.SOV
  SET.CUTOFF.FREQ
  data.buffer xsect[ ! , 1 ] SMOOTH data.buffer xsect[ ! , 1 ] := \ voltage now holds low pass
filtered data
  data.buffer xsect[ ! , 2 ] SMOOTH data.buffer xsect[ ! , 2 ] := \ current now holds low pass
filtered data
  data.buffer xsect[ ! , 3 ] SMOOTH data.buffer xsect[ ! , 3 ] := \ current now holds low pass
filtered data
  RELEASE.OVERLAY
;
\ *********************************************************************
\
\
\ *********************************************************************
: stat
\  STACK.CLEAR
\  CR CR ." Avg Current MEAN = " current MEAN . ." RMS = " current current * []sum
#samples/channel / sqrt .
\  CR ." Current Max = " current []MIN/MAX . ." Min = " .
\  CR ." Sdev Current = " current VARIANCE SQRT .
\  CR CR ." Avg Voltage MEAN = " voltage MEAN . ." RMS = " voltage voltage * []sum
#samples/channel / sqrt .
\  CR ." Voltage Max = " voltage []MIN/MAX . ." Min = " .
\  CR ." Sdev Voltage = " voltage VARIANCE SQRT .
\  CR CR ." Hit <return> to continue
\  wait.for.CR          \ loop until key hit
;
\ *********************************************************************
\
\
\ *********************************************************************
\ Computes the DFT of the waveform on top of stack
\ [ waveform -- ]
: fourier.transform
   STACK.CLEAR
   CR CR ." Enter Channel Number  1 Current "
      CR ."                   2 Light   "
      CR ."                   3 Field Probe  -> " #INPUT channel.no :=
```

```
\ CR ." Enter Smoothing Cutoff Frequency in Cycles/Point (0.03 - 0.5) -> " #INPUT
  LOAD.OVERLAY WAVEOPS.SOV
.1  SET.CUTOFF.FREQ
   " Discrete Fourier Transform"
    data.buffer xsect[ ! , channel.no ]
   channel.no
   CASE
    1 OF " Current "
      ENDOF
    2 OF " Light "
      ENDOF
    3 OF " Field Probe "
      ENDOF
    ENDCASE
   " Frequency (Hz) "
  CR CR ." ***** Calculating DFT ***** "

   FFT                              \ Compute FFT
   ZMAG                                \ Get Magnitude

   \ amplitude array of frequencies on stack now
   sub[ 0 , #samples/channel 2 / ]     \ get real part
   SMOOTH                              \ smooth amplitude
\  3.63569e-3 *                     \ empirical madigan factor for real units
   gpra []ramp                  \ set up frequency array
   ?conversion.delay 1E-3 *           \ calc time between samples
   #.of.channels *                  \ calc time between samples for each
   #samples/channel * INV             \ channel and convert to frequency
   gpra * gpra :=            \ per point, scale frequency array
   1 gpi :=
   BEGIN                            \ drop part of spectrum below
    gpra [ gpi ]
    30. >                        \ ?100 Hz
    1 gpi + gpi :=
   UNTIL
   SUB[ gpi , #samples/channel 2 / gpi - ]     \ only real half of power on stack
   gpra SUB[ gpi , #samples/channel 2 / gpi - ]
   SWAP                         \ and they are backwards so swap them
   plotter
   RELEASE.OVERLAY
;
\ ***********************************************************************
\
\
\ ***********************************************************************
: dump   \ dumps present contents of buffers to ASCII file
  name.file
```

```
  fname DEFER> OUT>FILE    \ open text file
\  CR ." ******** Writing to Text File ******** "
  CONSOLE.OFF
  #samples/channel 1 + 1 DO
  I . ." ,"
  data.buffer xsect[ I , 1 ] . ." ,"
  data.buffer xsect[ I , 2 ] . ." ,"
  data.buffer xsect[ I , 3 ] . ." ,"
  CR
  LOOP
  OUT>FILE.CLOSE
;
\ *********************************************************************
\
\
\ *********************************************************************
: test   \ dumps a a/d channel to screen
  RTI-800/815
  A/D.INIT
  BEGIN
  A/D.IN .                    \ start acquisition
  CR 100 MSEC.DELAY
  ?KEY
  UNTIL
;
\ *********************************************************************
\
\
\ *********************************************************************
: go
  STACK.CLEAR
  set.defaults
  101 1 DO
   NORMAL.DISPLAY SCREEN.CLEAR INTEN.OFF INVERSE.OFF CR CR CR CR
   ."       DATA ACQUISITION AND ANALYSIS PROGRAM       " CR CR CR
   ."  <1> FILE NAME          <2> LIVE ACQUIRE        <3> DISK ACQUIRE " CR
   ."  <4> TIME DATA PLOT      <5> SMOOTH DATA         <6> FOURIER
TRANSFORM " CR
   ."  <7> AMPLITUDE HISTOGRAM <8> CHANNEL vs CHANNEL   <9> SAMPLE
FREQUENCY " CR
   ."  <S> STATISTICAL         <Q> QUIT " CR
   CR ."  THE ACTIVE FILE NAME IS : " fname "TYPE
   CR CR ."  Select a key -> "
   KEY DUP ASCII" "TYPE
   CASE
    49 OF name.file                    ENDOF
    50 OF data.to.screen acquire.live      ENDOF
    51 OF acquire.disk                 ENDOF
```

```
  52 OF time.trace                      ENDOF
  53 OF smooth.data                     ENDOF
  54 OF fourier.transform               ENDOF
  55 OF time.amplitude.histogram        ENDOF
  56 OF channel.vs.channel              ENDOF
  57 OF set.frequency                   ENDOF
  115 OF stat                           ENDOF
  83 OF LEAVE -1 4 FIX.FORMAT           ENDOF
  81 OF LEAVE -1 4 FIX.FORMAT           ENDOF
  83 OF LEAVE -1 4 FIX.FORMAT           ENDOF
  113 OF LEAVE -1 4 FIX.FORMAT          ENDOF
  NOP
 ENDCASE
 LOOP
;
go
```

APPENDIX B
WELDING DATA

A. Data for Welds with 13-mm CTOD (Voltage in V and Current in A)

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
v240040	233.2	24.2	240.1	24.3	499.5	0.0	57.1	3.0	38.1	8.1	SC
v245040	237.5	24.5	239.9	24.6	499.5	111.8	33.9	2.1	37.0	9.1	SC
v250040	234.4	25.0	235.0	25.0	439.0	7.8	16.5	1.3	39.8	10.6	DS
v255040	238.7	25.6	238.8	25.6	263.2	221.7	3.0	0.1	26.5	24.8	DS
v260040	240.6	26.0	240.6	26.0	252.0	229.0	2.8	0.1	26.8	25.1	DS
v265040	250.4	26.6	250.5	26.6	263.2	238.3	2.7	0.1	27.2	25.7	DS
v270040	260.6	27.0	260.6	27.0	278.3	247.1	3.0	0.1	29.0	26.1	DS
v275040	264.1	27.5	264.1	27.5	274.4	250.0	3.1	0.1	27.9	25.0	DS
v280040	245.5	28.1	245.5	28.1	262.7	223.1	3.4	0.1	28.7	27.2	DS
v285040	249.2	28.5	249.2	28.5	258.3	235.4	3.0	0.1	29.3	27.6	DS
v290040	258.7	29.0	258.8	29.0	266.1	220.7	2.9	0.1	29.9	27.9	DS
v295040	276.3	29.5	276.3	29.5	283.7	257.3	2.2	0.1	30.2	27.4	DS
v300040	280.7	30.0	280.8	30.0	294.9	250.5	3.1	0.2	32.4	28.1	SS
v305040	283.7	30.5	283.7	30.5	294.4	263.7	2.9	0.1	31.4	29.7	SS
v310040	288.4	31.0	288.5	31.0	306.6	264.6	3.7	0.2	32.2	29.8	SS
v250045	249.3	25.1	252.6	25.2	499.5	0.0	40.5	2.6	38.5	8.7	SC
v255045	252.2	25.6	254.6	25.7	499.5	70.3	34.6	2.0	38.9	8.9	SC
v260045	267.3	26.0	267.4	26.0	309.1	224.1	8.4	0.5	32.5	18.8	DS
v265045	273.2	26.5	273.2	26.5	297.9	245.6	4.4	0.3	32.1	24.9	SS
v270045	272.2	27.0	272.3	27.0	308.6	229.5	5.7	0.3	30.4	25.5	SS
v275045	279.6	27.5	279.6	27.5	298.3	260.7	3.2	0.2	30.0	26.5	SS
v280045	294.2	28.0	294.2	28.0	310.5	281.7	3.1	0.2	30.6	26.9	SS
v285045	294.7	28.6	294.8	28.6	305.7	282.2	2.9	0.2	30.6	26.9	SS
v290045	293.8	29.0	293.8	29.0	303.7	278.8	2.7	0.1	30.7	28.1	SS
v295045	293.8	29.5	293.8	29.5	310.5	278.8	2.6	0.1	30.2	28.8	SS
v300045	297.7	30.1	297.7	30.1	313.0	276.4	2.7	0.1	32.1	28.7	SS
v305045	307.4	30.6	307.4	30.6	330.1	285.6	3.7	0.1	31.1	29.1	SS
v310045	314.2	31.0	314.2	31.0	320.8	294.9	2.3	0.2	31.6	29.2	SS
v255050	266.4	25.6	269.6	25.7	499.5	20.0	41.1	2.2	50.0	9.6	SC
v260050	269.4	26.1	271.3	26.1	499.5	62.5	31.8	1.8	41.5	10.4	SC
v265050	280.6	26.5	280.9	26.5	345.2	220.7	11.7	0.8	37.5	22.1	SC
v270050	286.7	27.0	286.7	27.0	340.3	242.7	6.5	0.4	31.7	25.3	SS
v275050	292.0	27.5	292.1	27.5	306.2	269.5	3.6	0.2	30.6	26.6	SS
v280050	316.9	28.0	316.9	28.0	334.0	297.9	3.0	0.1	29.4	26.9	SS
v290050	331.0	29.1	331.0	29.1	340.8	316.9	2.4	0.1	30.8	28.0	SS
v300050	327.4	30.0	327.4	30.0	337.9	314.0	2.4	0.1	30.5	29.0	SS
v310050	333.2	31.0	333.3	31.0	358.4	306.6	2.5	0.1	33.3	30.1	SS
v260055	295.1	26.1	295.8	26.1	499.5	27.3	19.4	1.2	37.2	14.5	SC
v265055	304.3	26.6	304.6	26.6	404.8	187.5	13.3	1.0	41.8	19.9	SC
v270055	310.1	27.0	310.3	27.0	374.0	239.7	11.1	0.8	32.7	22.3	SC
v275055	318.9	27.5	318.9	27.5	348.1	294.9	4.6	0.3	31.5	26.2	SC
v280055	328.5	27.9	328.6	28.0	349.1	293.9	5.3	0.4	31.5	26.3	SC
v285055	332.6	28.5	332.7	28.5	353.0	311.0	5.2	0.4	32.6	25.7	SC
v290055	336.3	29.0	336.3	29.0	354.5	315.9	4.5	0.3	32.5	26.4	SS
v295055	333.0	29.5	333.1	29.5	356.4	308.1	5.2	0.4	33.5	28.2	SS
v300055	354.4	30.1	354.4	30.1	377.4	331.1	3.4	0.2	32.3	29.1	SS
v310055	357.9	31.0	357.9	31.0	377.4	336.9	3.0	0.2	32.9	29.3	SS
v270060	325.6	27.0	325.6	27.0	386.7	291.0	7.1	0.5	31.5	23.8	SC
v275060	325.1	27.6	325.3	27.6	460.4	272.0	10.5	0.8	33.1	12.4	SC
v280060	340.9	28.1	341.0	28.1	370.6	313.0	6.7	0.5	33.3	26.4	SC
v285060	343.1	28.5	343.1	28.5	368.2	308.6	5.9	0.4	31.7	26.4	SC

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
v290060	345.9	29.0	345.9	29.0	370.6	324.2	4.5	0.3	31.7	27.1	SS
v295060	350.8	29.5	350.8	29.5	368.7	325.7	5.4	0.3	32.2	27.9	SS
v300060	358.5	30.0	358.6	30.0	379.9	314.0	5.0	0.4	34.0	28.6	SS
v310060	367.2	31.0	367.2	31.0	383.3	353.0	2.9	0.2	32.8	29.9	SS
v320060	382.6	32.0	382.6	32.0	393.6	365.2	2.6	0.1	34.0	31.1	SS
v325060	397.2	32.5	397.2	32.5	415.0	379.9	2.7	0.1	33.4	30.0	SS
v330060	395.3	33.0	395.3	33.0	406.3	384.3	2.9	0.1	33.8	31.8	SS
a280065	355.1	28.1	355.1	28.1	373.5	334.0	4.6	0.4	31.0	25.3	SC
a285065	350.3	28.6	350.4	28.6	381.8	316.4	6.3	0.5	32.1	26.4	SC
a290065	369.5	29.1	369.5	29.1	391.1	347.7	4.9	0.4	31.8	27.3	SS
a295065	367.3	29.5	367.3	29.5	391.6	340.3	4.7	0.4	32.0	28.3	SS
a300065	366.1	30.0	366.1	30.0	393.6	333.0	4.8	0.4	32.8	28.7	SS
a310065	395.8	31.0	395.8	31.0	418.0	366.2	4.7	0.4	34.5	28.8	SS
a320065	403.2	32.0	403.2	32.0	421.9	382.3	3.9	0.3	35.5	30.1	SS
a330065	409.6	33.0	409.7	33.0	421.9	391.6	3.0	0.2	35.4	31.4	SS
a340065	415.4	34.0	415.4	34.0	423.3	382.8	2.3	0.1	35.4	32.9	SS
a350065	456.7	35.0	456.9	35.0	499.5	438.0	11.2	0.2	35.9	34.1	SS
v280065	313.4	28.0	313.7	28.1	410.2	241.7	13.5	0.7	39.3	22.9	SC
v285065	331.2	28.5	331.2	28.5	363.3	289.1	6.2	0.4	34.7	26.6	SC
v290065	332.9	29.0	332.9	29.0	355.5	296.9	5.5	0.4	32.3	27.1	SS
v295065	346.7	29.5	346.8	29.5	364.7	322.8	3.5	0.3	31.9	28.6	SS
v300065	367.4	30.1	367.4	30.1	387.2	343.8	4.4	0.3	33.0	28.9	SS
v310065	370.2	31.0	370.2	31.0	384.8	347.7	3.2	0.2	32.8	29.5	SS
v320065	372.5	32.1	372.5	32.1	386.2	360.8	2.5	0.1	33.2	31.1	SS
v330065	404.1	33.0	404.1	33.0	418.9	375.0	3.3	0.2	35.1	31.4	SS
v285070	357.3	28.5	357.4	28.5	394.5	314.0	8.7	0.4	31.5	25.5	SC
v290070	367.5	29.0	367.5	29.0	383.8	343.3	4.2	0.3	31.6	27.7	SC
v295070	362.9	29.6	362.9	29.6	385.7	340.3	4.6	0.4	32.0	27.7	SS
v300070	388.1	30.1	388.2	30.1	414.1	354.5	5.5	0.5	33.3	28.2	SS
v310070	396.5	31.0	396.5	31.0	422.4	368.7	4.8	0.4	33.9	29.7	SS
v320070	397.6	32.0	397.6	32.1	413.6	373.0	4.5	0.4	35.3	30.7	SS
v330070	397.9	33.1	398.0	33.1	415.0	369.1	3.6	0.3	35.8	31.8	SS
v340070	434.0	34.0	434.0	34.0	452.1	417.0	3.9	0.2	36.4	32.7	SS
v350070	454.7	35.1	454.7	35.1	471.7	439.0	4.2	0.2	36.7	34.1	SS
v290075	361.4	29.2	363.1	29.2	499.5	162.1	35.9	2.0	39.2	9.9	SC
v295075	390.6	29.5	390.7	29.5	417.5	354.5	7.7	0.5	32.8	27.2	SC
v300075	392.5	29.8	392.5	29.8	420.4	355.5	7.8	0.5	33.7	27.9	SS
v305075	399.8	30.6	399.8	30.6	428.2	359.4	7.8	0.5	33.6	27.5	SS
v310075	390.0	31.0	390.1	31.1	414.1	363.8	6.8	0.5	34.0	29.5	SS
v320075	408.8	32.1	408.8	32.1	437.0	385.7	4.3	0.3	34.5	30.6	SS
v330075	412.5	33.1	412.5	33.1	428.7	391.6	3.2	0.2	34.4	31.4	SS
v340075	438.4	34.1	438.4	34.1	461.9	410.2	4.3	0.3	37.4	32.5	SS
v350075	435.0	35.0	435.0	35.0	449.7	411.1	3.9	0.2	36.9	33.9	SS
v360075	447.4	36.0	447.4	36.0	458.0	418.5	3.1	0.1	37.9	34.9	SS
v290080	385.1	29.1	385.3	29.1	499.5	320.8	11.9	1.0	35.9	20.0	SC
v295080	384.7	29.5	384.8	29.5	452.1	345.2	7.6	0.6	36.2	26.4	SC
v300080	386.7	30.1	386.7	30.1	409.7	363.3	5.3	0.5	32.6	28.7	SS
v310080	404.5	31.0	404.6	31.0	439.0	374.5	6.4	0.5	34.0	28.5	SS
v320080	410.0	32.0	410.1	32.0	439.0	387.2	4.6	0.4	34.4	30.1	SS
v330080	418.8	33.0	418.8	33.0	442.9	396.0	4.9	0.3	35.7	31.2	SS
v340080	443.5	34.1	443.5	34.1	468.8	420.4	4.5	0.3	36.2	32.5	SS
v350080	444.9	35.0	445.0	35.0	481.4	424.3	4.6	0.3	37.0	33.4	SS
v360080	464.5	36.0	464.5	36.0	473.1	446.3	2.6	0.2	37.5	34.4	SS
v290085	397.1	29.1	397.4	29.1	499.5	332.0	16.6	1.4	36.6	19.0	SC
v300085	403.0	30.0	403.1	30.0	433.1	373.5	5.6	0.5	33.0	28.0	SC
v310085	422.1	30.9	422.2	30.9	483.9	360.4	10.4	0.7	36.6	25.4	SS
v320085	419.3	32.1	419.4	32.1	450.2	388.2	7.0	0.5	34.5	30.6	SS
v330085	429.6	33.1	429.6	33.1	461.9	397.0	6.4	0.3	35.6	31.3	SS

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
v340085	453.0	34.0	453.0	34.0	477.5	423.3	4.5	0.3	36.6	32.7	SS
v350085	460.0	35.0	460.0	35.0	487.3	442.9	5.4	0.2	37.0	33.8	SS
v360085	481.4	36.0	481.5	36.0	499.5	455.6	8.9	0.3	38.2	34.3	SS
v290090	407.6	29.1	408.2	29.2	499.5	313.0	21.5	2.0	46.3	16.5	SC
v300090	419.7	30.1	419.9	30.1	499.5	358.9	12.5	1.2	38.5	22.7	SC
v310090	444.9	31.1	445.0	31.1	499.5	386.7	9.2	0.7	36.7	28.9	SS
v320090	451.6	32.0	451.7	32.1	482.9	408.2	8.6	0.6	35.4	30.4	SS
v330090	475.3	33.0	475.3	33.0	498.5	441.9	6.4	0.5	36.2	29.5	SS
v340090	474.7	34.0	474.7	34.0	499.5	445.3	5.9	0.5	37.1	30.0	SS
v350090	497.1	35.0	497.1	35.0	499.5	471.7	3.8	0.4	37.7	32.9	SS
v290095	410.8	29.2	411.9	29.3	499.5	305.2	29.3	2.9	39.0	14.6	SC
13v30000	420.6	29.5	424.0	29.8	767.6	302.7	53.9	4.1	38.6	10.5	SC
13v30501	424.0	30.1	426.8	30.3	748.0	325.7	48.5	3.8	38.5	11.2	SC
13v31002	424.0	30.6	425.0	30.7	734.9	308.1	29.5	2.2	37.7	13.4	SC
13v31503	439.3	31.0	440.7	31.2	606.0	334.0	36.2	3.7	40.5	12.1	SC
13v32004	429.8	31.5	430.9	31.7	590.8	326.7	30.5	3.5	39.5	13.8	SC
13v32505	453.5	32.0	454.0	32.1	558.6	381.3	21.0	2.8	37.6	16.9	SC
13v34006	460.4	33.4	460.6	33.5	535.2	408.7	12.7	1.1	37.1	26.0	SS
13v36007	501.3	35.3	501.7	35.3	574.7	425.3	20.6	0.7	37.7	32.8	SS

B. Data for Welds with 19-mm CTOD (Voltage in V and Current in A)

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
V2900961	191	29.4	193	29.4	352	121	31	0.4	31.0	25.7	GB
V3201198	190	32.2	192	32.2	274	115	31	0.3	33.9	29.7	GB
V3401507	201	34.0	206	34.0	282	83	48	0.4	37.0	32.5	GB
V3501512	221	35.1	225	35.1	307	112	43	0.4	37.0	33.3	GB
V3100804	211	31.0	211	31.0	252	153	18	0.2	32.9	29.7	GB
V3151035	213	31.6	215	31.6	270	142	31	0.3	33.1	30.4	GB
V3001003	209	30.0	212	30.0	305	136	35	0.4	32.5	25.7	GB
V3051009	208	30.5	311	30.5	315	114	40	0.4	31.8	28.1	GB
V3151059	216	31.5	219	31.5	273	134	35	0.3	32.4	29.7	GB/D
V2900950	229	29.1	229	29.1	252	180	7	0.2	30.0	28.4	GB/D
V2800480	204	28.0	205	28.0	460	37	17	0.7	35.5	12.3	GB
V2850594	206	28.5	207	28.6	444	127	21	0.6	39.8	12.4	GB
V2900980	215	29.1	217	29.1	289	109	26	0.4	38.0	26.5	GB
V2950988	217	29.6	218	29.6	267	154	26	0.3	32.2	28.0	GB
V3000997	226	29.9	228	29.9	330	157	26	0.3	31.1	27.2	GB/D
V3100797	225	31.0	225	31.0	255	148	15	0.3	33.2	29.7	GB/D
V3151069	225	31.6	226	31.6	265	143	26	0.3	32.6	30.9	GB/D
V3201211	212	32.1	216	32.1	295	125	39	0.4	33.1	30.3	GB
V3401501	236	34.1	237	34.1	280	148	17	0.2	35.2	31.8	SC/G
V3501526	244	35.0	246	35.0	339	135	33	0.4	39.6	33.4	GB/D
V2900967	228	29.0	228	29.0	247	192	6	0.1	29.8	27.7	GB
V3050702	227	30.5	227	30.5	248	191	8	0.2	31.4	29.0	DS
V3151044	236	31.6	237	31.6	262	192	14	0.2	32.4	30.0	GB/D
V3201220	221	32.0	222	32.0	281	142	23	0.3	33.8	30.8	GB
V3301373	232	33.0	233	33.0	275	154	24	0.3	34.0	31.3	GB
V3201260	246	32.0	246	32.0	282	177	12	0.2	32.8	29.2	DS
V3401525	245	34.0	246	34.0	273	178	15	0.2	34.9	32.6	GB/D
V3501535	276	34.9	277	34.9	292	220	6	0.3	35.9	33.0	DS/S
V2800501	213	28.0	214	28.1	500	27	25	1.5	41.4	12.1	GB
V2850602	222	28.5	223	28.5	245	187	7	0.2	29.8	27.3	GB
V2900000	231	29.2	231	29.2	246	214	4	0.2	30.3	27.9	GB
V2950150	234	29.6	234	29.6	248	219	4	0.2	31.2	28.1	GB/D
V3000265	220	30.0	220	30.0	253	164	10	0.2	30.9	28.5	GB/D
V3050690	248	30.6	248	30.6	263	225	4	0.2	31.5	27.2	DS
V3100818	235	31.0	235	31.0	255	191	11	0.2	31.7	29.5	DS
V3151076	250	31.6	250	31.6	266	231	5	0.2	32.3	30.5	DS
V3201252	234	31.9	234	31.9	260	177	8	0.2	32.8	31.1	GB/D
V3301382	232	33.0	233	33.0	272	169	21	0.3	33.8	31.0	GB/D
V3201227	222	32.0	224	32.0	285	147	28	0.3	32.9	30.1	DS
V3301350	232	33.1	232	33.1	258	170	9	0.2	33.8	31.7	GB
V3501504	287	35.0	287	35.0	301	262	5	0.3	37.0	32.2	SS
V2900021	235	28.8	235	28.8	245	210	3	0.2	29.4	27.4	GB/D
V3151083	260	31.6	260	31.6	286	233	5	0.2	32.3	30.0	DS
V3201244	247	32.0	247	32.0	270	198	6	0.2	33.3	30.5	DS
V3301360	254	33.1	254	33.1	270	226	5	0.2	35.6	31.8	DS
V3401537	259	34.1	259	34.1	280	239	6	0.2	36.0	32.1	SS
V2800518	229	28.0	229	28.0	248	210	5	0.2	28.7	26.4	GB
V2850622	231	28.5	231	28.5	248	216	4	0.2	29.4	27.0	GB
V2900040	234	29.0	234	29.1	244	219	3	0.2	30.2	27.6	DS
V2950161	260	29.5	260	29.5	276	240	4	0.2	30.8	26.6	DS
V3000321	233	30.0	233	30.0	248	206	5	0.2	31.0	28.3	GB/D
V3050710	249	30.5	249	30.5	264	227	4	0.2	31.3	26.8	DS/S
V3100837	247	30.9	247	30.9	262	220	5	0.2	32.5	27.7	DS/S

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
V3151051	259	31.6	259	31.6	284	234	7	0.2	32.3	29.5	DS/S
V3201236	253	31.9	253	31.9	278	231	7	0.2	32.9	29.6	SS
V3301367	261	33.0	261	33.0	279	227	5	0.2	34.1	31.5	DS
V3301356	269	33.0	269	33.0	281	235	5	0.2	35.3	31.5	SS
V3401547	268	34.0	268	34.0	288	250	6	0.2	35.3	32.2	SS
V3601611	324	35.8	325	35.8	411	259	30	0.4	38.1	33.8	SS
V2850634	249	28.5	249	28.5	305	159	7	0.4	36.5	25.0	GB/D
V2900057	249	28.9	249	28.9	273	203	5	0.4	38.6	25.0	SC/G
V2950176	259	29.5	260	29.5	274	237	5	0.2	30.0	25.8	DS/S
V3000358	260	30.0	260	30.0	274	234	5	0.2	30.8	28.3	SS
V3000344	250	30.0	250	30.0	272	216	6	0.2	31.3	28.4	DS
V3050726	257	30.5	257	30.5	285	184	6	0.3	34.3	28.4	DS/S
V3100851	258	31.0	258	31.0	281	229	6	0.3	31.7	27.8	SS
V3151090	272	31.5	272	31.5	291	239	5	0.2	32.2	29.7	SS
V3201272	275	32.0	275	32.0	309	249	6	0.2	33.0	30.2	SS
V2800536	245	28.0	246	28.1	500	0	26	1.5	39.0	12.8	SC/G
V2850655	252	28.5	253	28.5	459	49	15	0.9	40.2	17.1	SC/G
V3301390	290	33.0	290	33.0	311	268	5	0.2	34.3	31.6	SS
V3401557	297	34.0	297	34.0	320	273	5	0.2	36.7	31.4	SS
V3501500	313	35.1	313	35.1	328	280	5	0.3	35.6	31.8	SS
V3701655	326	37.1	326	37.1	345	287	7	0.3	39.2	35.2	RS
V3801706	345	38.0	345	38.0	371	290	8	0.3	41.9	35.1	RS
V2800549	253	28.0	256	28.2	500	0	42	2.9	40.7	6.3	SC/G
V2850665	253	28.5	253	28.5	444	27	26	1.7	40.6	13.1	SC/G
V2900074	265	29.0	266	29.0	359	170	14	1.2	40.1	20.4	SS
V2950191	272	29.4	272	29.4	294	225	5	0.3	33.9	25.8	SS
V3000373	268	30.0	268	30.0	282	247	5	0.2	31.5	28.3	SS
V3050736	270	30.5	270	30.5	288	235	5	0.3	32.3	28.7	SS
V3100860	276	30.9	277	30.9	314	238	9	0.3	32.9	28.1	SS
V3151100	288	31.6	288	31.6	310	264	6	0.2	32.6	29.8	SS
V2850676	254	28.4	256	28.5	500	27	31	2.2	45.2	13.7	SC/D
V2800562	260	28.0	264	28.2	500	28	52	3.1	40.1	11.8	SC
V2900092	286	28.9	286	28.9	303	261	3	0.3	31.4	25.9	SS
V3000444	284	29.9	284	29.9	299	246	5	0.3	35.8	28.0	SS
V3151111	289	31.5	289	31.5	308	267	6	0.2	32.5	29.7	SS
V3201292	296	32.0	296	32.0	315	265	5	0.2	33.9	27.8	SS
V3201282	296	32.4	296	32.4	313	248	5	0.2	34.3	31.0	SS
V3401582	311	34.0	311	34.0	325	292	4	0.2	35.0	31.5	SS
V3401568	311	34.0	311	34.0	327	280	4	0.2	35.4	32.1	SS
V3601617	348	36.0	348	36.0	363	322	4	0.2	38.3	33.5	SS
V3701728	320	37.6	320	37.6	339	293	7	0.2	39.1	36.0	RS
V3801713	358	38.0	358	38.0	378	331	6	0.2	40.4	36.3	RS
V2850683	264	28.5	267	28.7	500	25	38	2.3	41.1	12.7	SC/D
V3050753	272	30.5	272	30.5	441	158	20	1.4	40.2	16.2	SS
V3100874	291	31.0	291	31.0	330	252	9	0.3	34.4	29.0	SS
V2800580	267	28.0	273	28.2	500	2	55	3.4	41.0	11.7	SC
V2900115	289	29.0	289	29.1	350	142	11	0.7	38.5	22.5	SS
V3000459	281	30.1	283	30.2	500	63	34	2.2	50.0	14.1	SS
V3151121	297	31.7	297	31.7	369	69	14	0.8	42.3	25.1	SS
V3201299	305	32.0	305	32.0	326	259	5	0.2	33.2	30.6	SS
V3301400	312	33.1	312	33.1	330	282	5	0.2	33.8	30.9	SS
V3401603	314	34.1	314	34.1	330	293	5	0.2	34.7	32.6	SS
V3501542	359	34.9	359	34.9	381	315	5	0.2	35.9	32.4	SS
V3701663	360	36.9	360	36.9	376	340	5	0.3	38.3	33.6	RS
V2950203	299	29.5	299	29.5	299	246	6	0.3	32.4	25.7	SS
V3050764	289	30.6	290	30.6	491	75	28	1.8	41.7	16.1	SS
V3100885	302	31.0	302	31.1	384	158	14	0.6	39.4	24.4	SS
V3801720	375	38.0	375	38.0	397	338	8	0.2	39.1	34.8	RS

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
V280068	288	28.1	289	28.1	498	37	25	2.2	39.8	14	SC
V3000470	290	30.0	294	30.1	500	75	51	2.9	39.6	13.0	SC
V3050776	295	30.5	298	30.6	500	63	45	2.7	40.7	13.8	SC
V3151128	320	31.5	321	31.5	451	112	29	1.4	41.5	18.3	SS
V3201309	307	32.0	307	32.0	327	250	6	0.3	33.8	28.3	SS
V3301412	315	33.0	315	33.0	331	286	4	0.2	33.7	31.5	SS
V3401613	328	34.0	328	34.0	348	291	6	0.2	35.2	31.7	SS
V3601625	379	36.0	379	36.0	405	344	5	0.3	37.0	33.3	SS
V280072	298	28.1	300	28.2	500	103	34	2.5	38.8	13.1	SC
V2900137	294	29.0	295	29.1	500	53	28	1.9	41.7	12.8	SC
V3051179	304	30.6	305	30.6	500	190	26	1.5	43.4	13.8	SC
V051189	311	30.6	313	30.6	450	166	30	1.6	41.2	18.7	SC
V3151136	343	31.4	344	31.4	439	203	25	1.1	38.4	27.0	SC
V3201320	308	32.1	309	32.2	483	91	30	1.5	44.2	21.8	SC
V3301423	325	33.0	325	33.0	338	304	4	0.2	33.7	31.7	SS
V3401620	342	34.0	343	34.0	435	211	14	0.7	42.5	19.2	SS
V3701672	401	37.0	402	37.0	422	355	6	0.2	37.7	33.3	RS
V2950216	318	29.6	320	29.6	500	95	33	2.2	45.3	13.1	SC
V3501554	391	35.0	391	35.0	409	372	4	0.3	36.3	32.0	SS/R
V3701671	378	33.8	378	33.8	396	354	5	0.2	34.7	32.3	SS
V3701698	386	37.0	386	37.0	403	368	5	0.2	39.1	35.4	RS
TEST	320	28.1	324	28.3	500	115	49	3.4	39.2	12.2	SC
V2901016	292	29.0	304	29.2	500	33	83	3.7	40.5	11.1	SC
V3050116	324	30.4	326	30.6	500	59	41	2.8	41.4	13.6	SC
V3151142	350	31.5	351	31.5	463	242	31	1.4	39.9	24.5	SC
V3201335	317	32.0	318	32.0	420	147	25	1.2	40.5	26.1	SC
V3301441	358	33.0	358	33.0	382	307	7	0.2	34.2	29.8	SS
V3301433	334	33.0	334	33.0	351	313	4	0.2	34.0	31.5	SS
V3401632	360	33.9	360	33.9	383	319	8	0.4	36.4	32.1	SS
V3601633	395	36.1	395	36.1	419	459	5	0.3	36.7	34.3	RS
V3501565	401	35.0	401	35.0	419	377	5	0.2	35.6	31.3	RS
V3201754	373	31.9	374	31.9	435	246	15	0.6	35.5	27.3	SC
V3151151	339	31.6	340	31.7	476	191	31	1.6	42.7	18.5	SC
V3301450	365	32.9	365	32.9	390	335	6	0.3	34.9	30.8	SS
V3301468	362	32.9	362	32.9	383	332	8	0.4	35.4	30.9	SS
V3401640	360	33.9	360	33.9	401	284	10	0.6	39.8	30.3	SS
V3501575	407	35.0	407	35.0	421	380	5	0.2	35.8	31.9	RS
V3601637	424	36.0	424	36.0	437	405	3	0.2	37.2	33.2	RS
V3701717	391	37.0	391	37.0	407	361	6	0.3	37.9	33.4	RS
V3701685	418	37.0	418	37.0	429	373	4	0.3	37.9	35.1	RS
V2950233	341	29.5	343	29.6	500	128	36	2.3	46.0	7.3	SC
V2901021	312	28.9	321	29.2	500	91	72	3.8	43.5	10.5	SC
V3051170	346	30.5	348	30.6	500	211	38	2.2	39.0	15.3	SC
V3151160	339	31.5	341	31.6	500	144	41	2.4	40.4	15.6	SC
V3201750	377	31.8	378	31.8	500	203	29	1.0	38.8	18.2	SC
V3301479	348	32.9	349	32.9	388	297	11	0.7	37.1	28.0	SS
V3301761	384	33.0	384	33.0	431	356	9	0.4	35.1	30.8	SS
V3301461	353	33.0	353	33.0	483	243	19	1.1	42.3	25.3	SS
V3401774	399	34.0	399	34.0	415	369	5	0.3	35.5	31.1	SS
V3301766	384	33.1	384	33.1	438	350	9	0.4	35.4	30.8	SC
V3401784	413	33.9	413	33.9	426	385	5	0.2	35.2	32.4	SS
V3501586	412	35.0	412	35.1	431	375	9	0.4	36.9	30.7	SS
V3401665	374	35.9	374	35.9	472	263	18	1.0	41.8	30.1	SS
V3601645	435	36.1	435	36.1	464	402	8	0.3	38.0	34.5	RS
V3701695	431	37.0	431	37.0	443	413	4	0.3	38.5	35.0	RS
V2950244	330	29.6	335	29.9	500	122	59	4.0	50.0	11.0	SC
V2901028	327	28.9	338	29.3	500	97	85	4.7	50.0	10.6	SC
V3401792	422	34.0	422	34.0	441	394	6	0.3	35.8	32.4	SC

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
V3501600	448	35.1	448	35.1	463	424	5	0.3	36.0	33.3	RS
V3401801	414	34.1	414	34.1	436	369	9	0.4	36.2	32.6	SS
19v32008	373.3	31.4	374.0	31.6	477.1	301.3	22.5	3.3	39.5	15.2	SC
19v33009	375.4	32.6	376.0	32.7	467.8	276.4	20.9	2.6	40.3	18.4	SC
19v34010	382.8	33.6	382.9	33.6	453.6	334.5	10.9	1.2	39.5	25.3	SC
19v35011	395.8	34.5	395.9	34.6	438.0	358.9	7.6	0.8	38.9	30.3	SC
19v36012	398.3	35.4	398.4	35.4	418.0	377.4	5.8	0.6	37.9	34.1	RS
19v35513	402.7	35.0	402.7	35.0	424.3	378.9	6.4	0.7	38.3	33.1	RS
19v37014	409.9	36.4	410.0	36.4	427.2	385.3	5.3	0.5	38.5	35.2	RS

C. Data for Welds with 25-mm CTOD (Voltage in V and Current in A)

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
v280040	187.4	28.0	188.7	28.0	356.4	0.0	21.9	0.5	35.0	19.5	GB
v285040	190.1	28.5	190.2	28.5	207.0	171.4	5.1	0.2	31.0	27.8	GB
v290040	188.7	29.1	189.4	29.1	255.4	143.1	15.5	0.2	32.0	27.3	GB
v295040	189.5	29.5	190.8	29.5	362.3	129.4	22.0	0.5	35.9	12.2	GB
v300040	195.9	30.0	196.2	30.0	225.6	156.7	10.7	0.2	30.9	28.3	GB
v305040	194.5	30.5	195.6	30.5	242.2	82.0	20.6	0.3	35.0	28.9	GB
v310040	196.8	31.0	197.6	31.0	246.6	144.5	18.3	0.2	31.8	29.5	GB
v315040	197.5	31.6	199.3	31.6	292.0	133.8	26.1	0.3	32.4	29.9	GB
v320040	208.2	32.0	209.8	32.0	261.7	144.5	25.4	0.3	32.8	31.1	GB
v325040	203.9	32.5	207.4	32.5	309.6	111.8	37.9	0.4	33.5	30.5	GB
v330040	202.3	33.0	207.5	33.0	358.9	81.5	46.2	0.5	35.1	30.9	GB
v335040	204.1	33.6	207.5	33.6	320.3	116.2	37.0	0.4	36.3	31.0	GB
v340040	210.7	34.0	215.5	34.0	329.1	74.2	45.1	0.5	35.5	31.7	GB
v290043	199.5	29.1	201.7	29.1	496.1	0.0	30.0	0.7	37.0	13.6	GB
v295043	200.4	29.5	200.6	29.5	242.2	149.9	9.0	0.3	31.8	26.9	GB
v300043	199.9	30.1	200.4	30.1	285.2	101.1	13.1	0.3	34.2	25.7	GB
v305043	208.0	30.4	208.7	30.4	333.5	129.9	17.8	0.3	35.0	26.4	GB
v310043	205.3	31.1	206.4	31.1	351.1	135.7	21.3	0.3	32.1	28.3	GB
v315043	200.0	31.5	205.2	31.5	499.5	0.0	45.5	0.8	36.4	12.0	GB
v320043	203.7	32.1	205.1	32.1	294.4	122.1	24.2	0.4	37.9	30.2	DS
v325043	214.6	32.5	215.8	32.5	280.3	121.1	22.7	0.3	33.7	31.2	DS
v290045	214.7	29.1	214.8	29.1	240.2	188.5	4.5	0.2	30.0	28.1	GB
v295045	211.6	29.5	211.6	29.5	225.6	181.6	5.0	0.2	31.3	28.4	DS
v300045	213.8	30.0	213.9	30.0	226.6	197.3	4.2	0.2	31.2	29.1	DS
v305045	215.7	30.5	215.8	30.5	232.9	195.8	4.5	0.2	31.5	29.2	DS
v310045	218.0	31.1	218.1	31.1	231.4	199.2	4.3	0.2	32.2	30.4	DS
v315045	221.6	31.5	221.7	31.5	232.4	201.2	4.2	0.2	32.5	31.1	DS
v320045	219.2	32.1	219.9	32.1	320.3	130.4	17.3	0.4	34.0	29.4	DS
v325045	224.8	32.6	225.4	32.6	311.0	143.6	17.0	0.4	34.8	30.8	DS
v330045	224.9	33.0	225.2	33.0	317.9	138.7	12.5	0.3	34.7	31.4	DS
v335045	231.1	33.6	231.2	33.6	249.5	188.0	8.3	0.2	34.8	32.2	DS
v340045	230.6	34.0	230.9	34.0	257.3	156.3	10.9	0.4	35.7	32.7	DS
v345045	244.8	34.4	244.9	34.4	265.1	221.2	6.3	0.2	35.4	33.5	DS
v350045	243.3	35.0	243.4	35.0	265.6	214.8	6.6	0.2	35.7	34.2	DS
v285048	204.1	28.6	204.6	28.6	421.4	103.0	14.3	0.5	36.5	18.8	GB
v290048	203.9	29.1	204.6	29.1	414.6	125.0	17.2	0.6	42.0	25.0	GB
v295048	207.3	29.6	207.5	29.6	243.7	162.1	8.8	0.3	31.7	25.1	DS
v300048	211.0	30.1	211.5	30.1	323.7	118.2	15.3	0.4	33.7	26.1	DS
v280050	217.4	28.0	217.6	28.0	293.5	157.2	8.2	0.5	35.6	12.8	GB
v285050	218.7	28.5	218.7	28.5	236.3	194.8	5.7	0.2	29.3	27.0	GB
v290050	221.6	29.0	221.6	29.0	237.8	204.1	4.7	0.2	29.9	27.7	DS
v295050	221.7	29.5	221.8	29.5	238.8	198.7	5.5	0.2	30.3	28.7	DS
v300050	231.0	30.1	231.0	30.1	247.1	203.6	4.0	0.2	31.0	29.5	DS
v305050	236.5	30.6	236.6	30.6	253.4	220.7	3.5	0.2	31.6	29.3	DS
v310050	237.8	31.0	237.9	31.0	251.5	224.1	3.9	0.2	31.9	28.9	DS
v315050	236.0	31.5	236.0	31.5	248.0	204.6	3.7	0.2	32.2	30.7	DS
v320050	239.7	32.0	239.7	32.0	253.9	224.1	4.2	0.2	32.8	29.9	DS
v325050	252.9	32.5	253.0	32.5	268.6	209.0	4.9	0.2	34.3	30.9	DS
v330050	254.7	33.1	254.7	33.1	269.0	231.9	4.7	0.2	33.9	31.3	DS
v335050	259.1	33.5	259.2	33.5	279.3	233.9	5.0	0.2	34.3	31.9	DS
v340050	256.8	34.0	256.9	34.0	274.4	216.3	5.3	0.2	35.4	31.5	DS
v345050	258.0	34.5	258.1	34.5	278.3	204.6	6.5	0.2	35.4	31.8	DS
v350050	258.1	35.0	258.2	35.0	279.3	234.4	6.5	0.2	35.9	33.3	DS
v355050	269.7	35.5	269.8	35.5	295.4	231.4	6.2	0.2	38.1	33.8	DS

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
v360050	279.6	36.0	279.7	36.0	296.4	250.5	4.8	0.2	38.9	34.1	DS
v290053	226.8	29.0	227.3	29.0	348.1	161.6	15.4	0.5	34.0	26.2	GB
v295053	224.5	29.6	224.6	29.6	271.0	155.8	9.0	0.4	32.4	27.3	DS
v300053	225.2	30.1	225.3	30.1	247.1	202.1	6.2	0.3	31.2	28.2	DS
v305053	233.8	30.5	233.9	30.5	252.9	211.9	6.1	0.2	31.4	29.5	DS
v310053	236.7	31.1	236.7	31.1	249.5	212.9	4.8	0.2	32.0	30.1	DS
v290055	227.2	29.0	228.5	29.1	499.5	41.5	24.6	1.7	41.4	14.5	SC
v295055	231.2	29.5	231.4	29.5	266.1	199.2	8.8	0.5	38.2	24.5	SC
v300055	244.4	30.0	244.5	30.0	294.9	190.4	7.5	0.4	38.4	24.3	SC
v305055	243.4	30.4	243.5	30.4	265.6	209.0	7.0	0.3	32.1	29.4	SS
v310055	239.1	31.1	239.2	31.1	267.6	201.2	7.0	0.3	32.2	29.4	SS
v315055	243.2	31.4	243.3	31.5	259.8	216.3	6.6	0.3	32.6	30.4	SS
v320055	245.8	32.0	245.9	32.0	267.1	203.6	8.2	0.3	33.5	30.4	SS
v325055	257.8	32.5	257.9	32.5	276.4	226.1	6.9	0.2	33.4	31.3	SS
v330055	259.3	33.0	259.4	33.0	275.9	231.4	6.4	0.2	34.2	31.9	SS
v370055	275.5	36.0	275.6	36.0	298.3	247.6	6.7	0.2	37.8	34.1	SS
v280060	242.5	28.0	243.8	28.1	499.5	32.2	24.7	1.8	42.6	13.8	SC
v285060	248.2	28.5	248.7	28.6	361.3	190.4	15.9	0.9	40.9	17.5	SC
v290060	248.5	29.0	248.7	29.0	300.8	196.8	8.6	0.5	38.3	25.3	SC
v295060	258.4	29.5	258.5	29.5	313.5	207.0	6.8	0.3	33.3	28.0	SS
v300060	259.7	30.1	259.7	30.1	295.4	222.2	6.2	0.3	33.2	28.4	SS
v305060	262.3	30.5	262.3	30.5	281.7	234.9	5.7	0.2	32.2	29.0	SS
v310060	260.4	31.1	260.5	31.1	277.3	211.9	6.3	0.3	33.2	27.2	SS
v315060	264.1	31.5	264.2	31.5	284.7	230.0	5.7	0.2	32.9	29.5	SS
v320060	273.4	32.0	273.4	32.0	288.6	235.8	4.6	0.2	33.6	30.2	SS
v325060	281.4	32.5	281.5	32.5	293.9	262.2	3.9	0.2	33.3	28.7	SS
v330060	281.3	33.0	281.3	33.0	295.9	263.2	3.7	0.2	34.1	30.3	SS
v335060	283.1	33.5	283.1	33.5	295.4	260.7	4.0	0.2	35.1	32.2	SS
v340060	232.9	34.1	233.1	34.1	272.9	189.0	11.0	0.5	36.0	32.2	SS
v345060	243.9	34.5	244.1	34.5	266.1	192.9	9.1	0.3	36.7	32.8	SS
v350060	246.7	35.0	246.8	35.0	265.6	204.6	8.7	0.3	36.7	33.3	SS
v355060	248.5	35.6	248.7	35.6	271.5	207.5	9.5	0.4	36.8	34.5	SS
v360060	248.9	36.0	249.1	36.0	271.5	197.3	8.9	0.3	37.5	34.4	SS
v280065	260.0	28.0	262.1	28.1	499.5	96.7	32.9	2.1	38.9	14.6	SC
v285065	262.0	28.5	264.0	28.6	499.5	51.8	31.9	1.8	40.7	13.7	SC
v290065	262.0	29.0	263.2	29.1	464.8	147.5	25.9	1.6	39.4	15.1	SC
v295065	268.2	29.5	269.1	29.5	356.9	203.6	21.3	1.0	37.9	21.8	SC
v300065	265.2	30.0	265.9	30.0	335.9	170.9	18.9	1.0	37.2	18.7	SS
v305065	266.3	30.6	266.7	30.6	338.9	161.6	14.5	0.8	36.9	20.3	SS
v310065	276.7	31.0	276.8	31.0	309.1	185.5	7.1	0.4	40.0	27.4	SS
v315065	278.2	31.5	278.2	31.5	307.1	251.0	5.1	0.3	32.8	30.2	SS
v320065	278.1	32.0	278.2	32.0	309.1	252.9	5.9	0.3	33.0	28.1	SS
v325065	279.9	32.6	279.9	32.6	298.3	257.3	5.2	0.2	34.0	30.1	SS
v330065	282.8	33.0	282.9	33.0	298.3	257.8	5.4	0.2	33.9	31.6	SS
v335065	289.0	33.5	289.0	33.5	304.2	267.1	4.9	0.2	34.7	32.1	SS
v340065	292.3	34.1	292.3	34.1	304.7	256.3	4.7	0.2	35.1	32.4	SS
v345065	293.3	34.5	293.4	34.5	310.1	257.3	5.1	0.2	35.4	32.1	SS
v350065	300.1	35.0	300.1	35.0	319.3	280.3	4.6	0.2	35.8	33.9	SS
v355065	316.8	35.5	316.8	35.5	339.8	297.9	6.3	0.2	36.3	34.5	SS
v360065	310.2	36.0	310.2	36.0	330.1	284.7	4.7	0.2	36.8	35.0	RS
v365065	310.7	36.5	310.8	36.5	319.3	296.4	3.4	0.2	37.3	33.2	RS
v370065	321.6	37.0	321.6	37.0	336.9	299.3	4.5	0.2	39.5	34.8	RS
v280070	239.9	28.0	249.1	28.2	499.5	133.8	67.0	3.7	42.4	10.9	SC
v285070	242.1	28.6	249.7	28.8	499.5	30.8	60.8	3.8	43.8	11.7	SC
v290070	239.8	29.1	245.7	29.3	499.5	37.1	53.5	3.5	43.1	11.8	SC
v295070	240.8	29.5	246.9	29.8	499.5	71.3	54.7	3.7	44.1	11.6	SC
v300070	241.8	30.0	247.3	30.2	499.5	41.0	51.9	3.5	43.5	12.0	SC
v305070	246.3	30.4	249.8	30.6	499.5	61.0	42.1	2.7	43.4	12.9	SS

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
v310070	246.0	31.0	249.2	31.1	499.5	73.7	39.8	2.6	43.6	12.9	SS
v315070	242.6	31.4	246.4	31.6	499.5	59.1	43.2	3.1	43.7	14.1	SS
v320070	240.0	32.2	246.6	32.4	499.5	58.1	56.7	3.3	46.3	13.9	SS
v325070	247.8	32.6	250.2	32.7	499.5	59.1	34.7	2.1	43.8	12.1	SS
v330070	256.6	33.2	257.6	33.2	499.5	121.1	22.7	1.3	43.9	15.8	SS
v335070	257.0	33.5	257.9	33.5	485.4	76.2	21.7	1.2	44.2	19.1	SS
v340070	260.7	34.1	261.1	34.1	348.1	197.3	14.2	0.6	40.5	28.9	SS
v345070	258.5	34.6	258.8	34.6	333.5	197.8	12.8	0.6	38.7	31.3	SS
v350070	266.0	35.0	266.2	35.0	295.4	222.7	9.3	0.4	37.4	33.1	SS
v355070	278.5	35.5	278.6	35.5	296.9	230.0	7.6	0.4	37.0	33.0	SS
v360070	276.3	36.1	276.5	36.1	295.9	236.3	8.4	0.4	38.1	34.4	SS
v365070	275.2	36.5	275.4	36.5	295.4	224.6	9.1	0.4	38.7	33.9	RS
v370070	278.2	37.0	278.3	37.0	301.3	230.5	7.9	0.4	38.3	35.3	RS
v345075	323.2	34.6	323.3	34.6	336.9	284.2	5.8	0.3	35.9	33.4	SS
v350075	324.8	35.1	324.9	35.1	344.2	275.9	8.1	0.3	36.2	34.1	SS
v355075	326.5	35.5	326.6	35.5	344.2	290.0	6.6	0.3	36.6	34.3	SS
v360075	338.9	36.0	339.0	36.0	352.1	317.9	5.0	0.3	37.5	33.6	RS
v365075	346.6	36.5	346.6	36.5	361.8	307.1	5.6	0.3	37.7	35.5	RS
v370075	348.1	37.1	348.1	37.1	366.7	327.6	4.8	0.3	38.0	35.9	RS
v290080	294.0	29.1	295.5	29.2	499.5	60.1	30.5	2.3	40.1	13.3	SC
v295080	304.9	29.5	305.8	29.6	499.5	168.0	22.8	1.6	40.5	16.2	SC
v300080	311.3	30.1	311.6	30.1	430.7	211.9	13.7	1.0	37.2	18.3	SC
v305080	311.4	30.4	311.6	30.4	414.6	269.0	10.0	0.6	36.3	25.5	SC
v310080	321.7	31.0	321.7	31.0	345.7	292.5	5.7	0.2	32.7	29.3	SC
v315080	320.7	31.5	320.7	31.5	335.0	277.3	6.8	0.3	34.0	28.4	SS
v320080	324.6	32.1	324.7	32.1	339.4	296.4	5.1	0.2	33.8	30.9	SS
v325080	334.5	32.5	334.5	32.5	344.2	314.9	4.2	0.2	33.5	31.5	SS
v330080	335.2	33.0	335.2	33.0	350.6	318.8	4.7	0.2	33.7	31.6	SS
v335080	337.5	33.5	337.5	33.5	351.1	308.6	4.2	0.2	35.1	32.2	SS
v340080	340.6	34.1	340.6	34.1	351.1	324.2	3.7	0.2	34.8	32.8	SS
v345080	350.3	34.5	350.3	34.5	364.7	323.2	3.4	0.2	35.5	33.5	SS
v350080	357.4	35.0	357.5	35.0	376.0	338.4	4.1	0.2	35.8	33.6	RS
v355080	353.4	35.5	353.4	35.5	364.3	337.4	3.7	0.2	36.3	34.2	RS
v345085	341.3	34.5	341.4	34.5	359.9	298.8	7.3	0.3	36.5	32.8	RS
v350085	352.8	35.1	352.9	35.1	370.1	320.3	6.7	0.3	37.3	34.0	RS
v355085	353.3	35.5	353.3	35.5	369.1	314.0	5.5	0.3	36.7	33.1	RS
v360085	357.6	36.0	357.7	36.0	383.3	333.0	4.9	0.3	37.0	33.3	RS
v365085	355.4	36.5	355.4	36.5	372.1	320.8	5.3	0.4	37.6	34.7	RS
v370085	358.3	37.0	358.4	37.0	379.9	333.5	5.3	0.4	38.4	35.6	RS
v290090	309.9	29.0	311.0	29.1	499.5	164.1	26.1	2.5	41.5	14.6	SC
v295090	317.3	29.6	319.0	29.7	499.5	196.8	33.0	3.0	41.3	14.3	SC
v300090	310.6	29.9	313.3	30.1	499.5	129.4	41.2	3.2	42.0	14.6	SC
v305090	315.5	30.6	317.6	30.8	499.5	131.3	36.7	3.0	41.4	12.8	SC
v310090	331.2	30.9	331.4	30.9	392.6	239.7	11.0	0.7	38.1	26.6	SC
v315090	334.1	31.5	334.2	31.5	359.9	285.2	8.6	0.5	35.4	29.6	SS
v320090	338.2	32.0	338.4	32.0	377.4	285.2	11.0	0.6	38.9	28.7	SS
v325090	344.8	32.5	344.9	32.5	369.6	307.6	7.4	0.5	35.9	30.1	SS
v330090	344.8	33.0	344.9	33.0	365.2	310.1	7.1	0.4	35.7	31.4	SS
v335090	349.0	33.5	349.1	33.5	364.3	315.9	6.1	0.3	35.8	31.8	SS
v340090	361.8	34.0	361.9	34.0	380.9	336.4	5.0	0.3	36.1	30.9	SS
v345090	378.2	34.5	378.2	34.5	392.1	349.6	4.3	0.3	36.5	31.7	SS
v350090	380.2	35.0	380.2	35.0	394.5	343.3	4.9	0.3	36.7	31.7	SS
v355090	369.3	35.6	369.3	35.6	382.8	350.1	4.2	0.3	36.5	33.4	RS
v360090	372.8	36.0	372.8	36.0	385.3	352.1	4.1	0.3	36.9	33.4	RS
v350095	364.3	35.0	364.3	35.0	381.3	331.5	6.9	0.4	37.4	33.6	SC
v355095	367.5	35.5	367.5	35.5	386.7	325.7	6.9	0.4	38.1	32.8	RS
v360095	363.2	36.0	363.3	36.0	378.9	334.5	6.4	0.4	38.3	34.7	RS
v365095	375.5	36.5	375.6	36.5	390.6	350.1	6.0	0.4	38.3	35.6	RS

FILE NAME	CURRENT MEAN	VOLTAGE MEAN	CURRENT RMS	VOLTAGE RMS	CURRENT MAX	CURRENT MIN	CURRENT SDEV	VOLTAGE SDEV	VOLTAGE MAX	VOLTAGE MIN	TRANSFER MODE
v370095	383.7	37.0	383.8	37.0	401.4	351.1	6.0	0.4	38.5	35.0	RS
v370095	383.7	37.0	383.8	37.0	401.4	351.1	6.0	0.4	38.5	35.0	RS
v300100	339.2	30.1	341.1	30.2	499.5	165.5	36.1	3.1	40.7	13.1	SC
v305100	340.5	30.5	341.5	30.6	499.5	205.6	26.7	2.2	40.8	16.1	SC
v310100	345.0	31.0	345.3	31.0	427.7	217.3	13.6	1.1	42.1	23.5	SC
v315100	348.8	31.6	349.2	31.6	499.5	215.8	15.2	1.1	39.4	20.0	SC
v320100	354.7	31.9	355.1	32.0	477.1	181.2	18.0	1.3	41.7	18.1	SS
v325100	360.6	32.4	360.8	32.4	431.2	300.8	12.5	0.8	37.0	18.8	SS
v330100	364.8	33.1	365.2	33.1	441.9	273.4	17.5	1.0	39.5	25.8	SS
v335100	362.5	33.5	362.6	33.6	394.0	317.4	10.6	0.7	38.7	30.7	SS
v340100	373.2	34.0	373.3	34.0	398.4	346.7	8.1	0.6	36.7	32.2	SS
v345100	373.2	34.5	373.2	34.6	391.1	340.3	6.8	0.4	36.8	32.6	SS
v350100	373.0	35.0	373.1	35.0	393.1	335.9	5.6	0.4	37.1	31.1	SS
v355100	382.4	35.4	382.5	35.4	397.0	337.4	4.9	0.4	37.6	33.5	SS
v360100	394.5	36.0	394.5	36.0	409.2	371.1	5.1	0.4	38.0	34.1	SS
25v31016	339.4	30.4	340.4	30.7	459.0	270.0	26.5	3.9	40.5	16.1	SC
25v32017	340.3	31.5	341.1	31.7	426.8	267.6	23.3	3.6	40.5	17.8	SC
25v33018	348.3	32.6	348.7	32.7	437.5	284.2	18.1	2.4	40.6	19.8	SC
25v34019	347.8	33.6	348.1	33.6	408.2	288.6	13.0	1.6	39.8	24.1	SC
25v35020	358.4	34.5	358.5	34.5	412.6	318.4	8.5	0.9	39.6	30.9	RS
25v34521	357.0	34.0	357.1	34.0	410.2	291.5	8.5	0.9	39.1	25.4	RS
25v36022	362.7	35.5	362.7	35.5	383.3	335.0	5.5	0.5	38.5	34.0	RS
25v37023	378.9	36.5	379.0	36.5	400.4	359.9	4.9	0.4	38.5	35.6	RS